modern castings

AFS JULY, 1959

Magnesium Alloy Casting

■ ■ ■ Pg. 25

Arc Furnace Ventilation ■ ■ ■ Pg. 30

Castings Proving Ground

■ ■ ■ Pg. 33

of Angels and MISSILES

■ ■ ■ Pg. 28

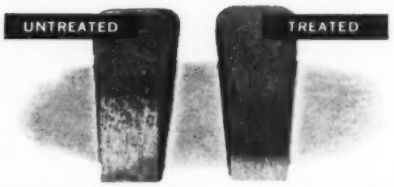
"No machining complaints since I used SMZ alloy"

You can eliminate chilled corners and hard spots in gray iron castings with ladle additions of "SMZ" alloy. Machining rates can thus be improved by as much as 25 per cent, giving you more satisfied customers.

"SMZ" alloy is the most widely used inoculant in the iron foundry industry. As little as 2 to 4 pounds of "SMZ" alloy per ton of iron are sufficient to eliminate chill in light castings. For harder irons of lower carbon and silicon contents, a larger addition of the alloy may be required.

For information on how "SMZ" alloy can improve the machineability of your castings, contact your UNION CARBIDE METALS representative. Ask for the booklet, "SMZ Alloy—An Inoculant for Cast Iron."

UNION CARBIDE METALS COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y.



These chill blocks show how "SMZ" alloy reduced chill in a 3.15% carbon, 1.80% silicon iron.

UNION CARBIDE METALS

Electromet *Brand Ferroalloys and other Metallurgical Products*

The terms "Electromet," "SMZ," and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle No. 145, Page 131-132

july, 1959
vol. 36, no. 1

modern castings

the technical magazine of the metalcasting industry

features

The Design Producibility of a Magnesium Alloy Casting
by W. Krzymowski and C. I. Miller 25
Of Angels and Missiles
by Joan Castle Joseff 28
How to Ventilate Electric Arc Furnaces
by D. M. Hysinger 30
Proving Ground for Metalcastings Progress 33

1959 Castings Congress Papers

Pressure Tightness of 85-5-5-5 Bronze, relationship of thermal gradients during solidification
by R. A. Flinn and C. R. Mielke 35
Method of Obtaining Castability and Maximum Field Service from Cast Products
by J. W. Beckham 43
Pinhole Occurrence in Malleable Castings, bonding clays as cause
by D. R. Jones and R. E. Grim 47
Industrial Engineering for the Small Foundry, a practical approach
by F. E. Noggle 51
How to Avoid Sand Segregation
by AFS Committee 8-F 62
High Strength Steel Castings, mechanical properties and processing techniques
by K. D. Holmes, J. Zotos and P. J. Ahearn 65
Core Boxes for Shell Cores
by J. E. Stock 71
Tin Effect on Structure and Properties of Flake and Nodular Graphite Cast Irons
by E. C. Ellwood 73
Cyclic Permanent Mold Operation, some thermal aspects
by C. L. Goodwin and H. Y. Hunsicker 81
Crust Separation Test For Investigation of Sand Expansion Defects
by P. W. Goad 86

departments

Advertisers and Their Agencies 128
AFS News 99
Chapter Meetings 111
Classified Advertising 120-121
Editor's Report 5
For the Asking 12
Foundry Trade News 116
Future Meetings & Exhibits. 2
Here's How 128
Let's Get Personal 118
Pouring Off the Heat 20
Obituaries 121
Products & Processes 7
Reader Service Card.....131-132

featurettes

Map of Steel Castings Industry 22
Radiography Assures Quality 127
Shellmolding .....*J. F. Oettinger*..... 139

future meetings and exhibits

SEPTEMBER

13-18 . . American Chemical Society, *Fall Meeting*. Atlantic City, N.J.

15-17 . . American Die Casting Institute, *Annual Meeting*. Edgewater Beach Hotel, Chicago.

21-22 . . Steel Founders' Society of America, *Fall Meeting*. The Homestead, Hot Springs, Va.

24-26 . . *AFS Missouri Valley Regional Foundry Conference*. University of Missouri, School of Mines & Metallurgy, Rolla, Mo.

28-Oct. 1 . . Association of Iron and Steel Engineers, *Annual Convention*. Sherman Hotel, Chicago.

28-Oct. 1 . . American Welding Society, *Fall Meeting*. Hotel Sheraton-Cadillac, Detroit.

29-Oct. 1 . . National Association of Corrosion Engineers, *Western Regional Conference*. Bakersfield Inn, Bakersfield, Calif.

OCTOBER

1-2 . . *Niagara Regional Foundry Conference*. Drumlins Country Club, Syracuse, N. Y.

2-3 . . AFS *Northwest Regional Foundry Conference*. Benjamin Franklin Hotel, Seattle.

3-10 . . International Committee of Foundry Technical Associations, *International Foundry Congress*. Madrid, Spain.

7-9 . . Gray Iron Founders' Society, *Annual Meeting*. Fairmont Hotel, San Francisco.

8-9 . . AFS *Michigan Regional Foundry Conference*. Pantlind Hotel, Grand Rapids, Mich.

8-10 . . American Society of Tool Engineers, *Semi-annual Meeting*. St. Louis.

10-13 . . Conveyor Equipment Manufacturers Association, *Annual Meeting*. Grand Hotel, Point Clear, Ala.

11-16 . . American Society for Testing Materials, *Pacific Area National Meeting & Exhibit*. Sheraton Palace Hotel, San Francisco.

12-17 . . National Industrial Sand Association, *Semi-annual Meeting*. The Greenbrier, White Sulphur Springs, W. Va.

15-17 . . Foundry Equipment Manufacturers Assn., *Annual Meeting*. The Greenbrier, White Sulphur Springs, W. Va.

16-17 . . AFS *New England Regional Foundry Conference*. Massachusetts Institute of Technology, Cambridge, Mass.

21 . . Cast Bronze Bearing Institute *Annual Meeting*. Bedford Springs Hotel, Bedford, Pa.

21-23 . . National Management Association, *National Conference*. Statler-Hilton Hotel, Detroit.

22-23 . . AFS *Ohio Regional Foundry Conference*. Deshler-Hilton Hotel, Columbus, Ohio.

23-24 . . Non-Ferrous Founders' Society, *Annual Meeting*. Bedford Springs Hotel, Bedford, Pa.

29-30 . . AFS *Purdue Metals Casting Conference*. Purdue University, West Lafayette, Ind.

NOVEMBER

2-6 . . American Society for Metals, *National Metal Exposition & Congress*. International Amphitheatre, Chicago.

6-7 . . National Foundry Association, *Annual Meeting*. Roosevelt Hotel, New York.

9-11 . . Steel Founders' Society of America, *Technical & Operating Conference*. Carter Hotel, Cleveland.

Gray Iron Approved for 800 F Service

The upper parameters for the use of cast iron at elevated temperatures have been established in an extensive research program sponsored by the ASTM-ASME Joint Committee on Effect of Temperature on the Properties of Metals. The study made by J. R. Kattus and B. McPherson at Southern Research Institute, Birmingham, Ala., established that the following alloys should sustain the indicated tensile loads for 10 years at 800 F: 1) Cr-Mo-alloyed gray iron . . . 30,000 psi; 2) Mo-alloyed gray iron . . . 25,000 psi; 3) Cr-Ni-Mo-Va-alloyed gray iron . . . 25,000 psi; 4) unalloyed ferritic nodular iron . . . 17,000 psi; and 5) unalloyed gray iron . . . 15,000 psi.

MODERN CASTINGS is indexed by Engineering Index, Inc., 29 West 39th St., New York 18. N. Y. and microfilmed by University Microfilms, 313 N. First St., Ann Arbor, Mich.
The American Foundrymen's Society is not responsible for statements or opinions advanced by authors of papers or articles printed in its publication.
Published monthly by the American Foundrymen's Society, Inc., Golf & Wolf Roads, Des Plaines, Ill. Subscription price in the U.S., $5.00 per year; elsewhere, $7.50. Single copies 50c. April, May and June issues $1.00. Entered as second-class mail at Pontiac, Ill. Additional entry at Des Plaines, Ill.

AUDITED PAID CIRCULATION ABC

THOUSANDS OF CarVer RAPID MULLERS NOW IN USE

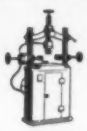
The most POPULAR, most PRACTICAL muller on the market . . . Here's why . . .

- The fastest! A batch every 75 seconds!
- Absolutely *no* lumps or wet spots!
- Easiest to clean! Just reach inside
- Only *one* moving part . . . no maintenance worries!
- 3 times lower initial investment than with most mullers!
- Works equally well with *any* kind of binder!

IF YOU COMPARE MULLERS CAREFULLY . . . YOU'LL CHOOSE CARVER

Only CarVer Has Everything For the CO_2 Process!

CARVER V & S Core Shooters



CARVER Automatic Gassing Apparatus

KRAUSS Taper Slot Core Vents

STEINEX available only from CARVER

MAIL COUPON TODAY

CARVER FOUNDRY PRODUCTS CO.
Muscatine, Iowa

I want to compare! Tell me more about Carver Rapid Muller.

NAME _____ TITLE _____

FOUNDRY _____

CITY _____ STATE _____

Circle No. 146, Page 131-132

LADLES UNLIMITED

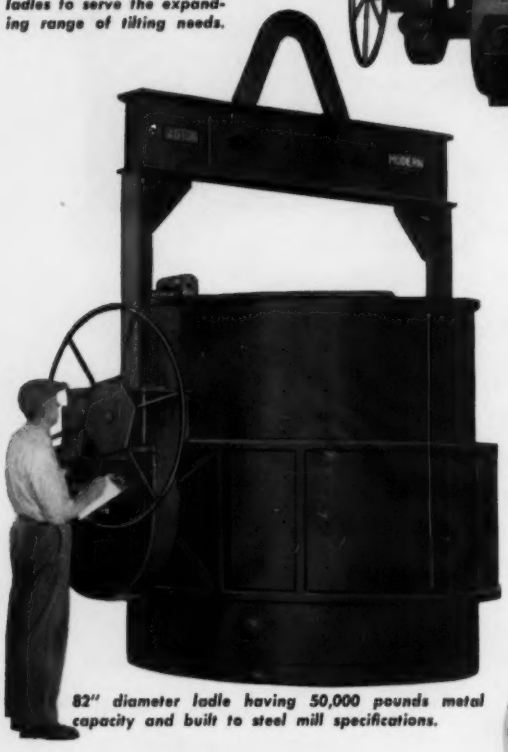
Wherever metal is treated, inoculated, distributed or poured — MECHANICALLY — the chances are good that the ladle equipment is MODERN! Ladles in all types and sizes are engineered to the metal loads and pouring conditions. There are no size limitations: You name it! We'll build it!

800 pound, straight-sided ladle with square bail and gearing. Seven standard gear sizes are available for ladles to serve the expanding range of tilting needs.

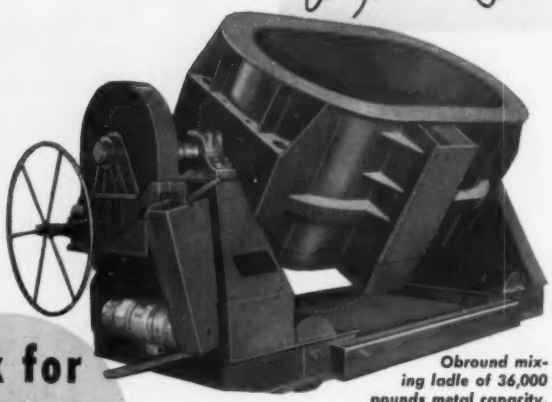
Modern 17½" tap diameter, tapered, covered ladle with No. 1 type shank, roller bearing trunnions and detachable bail.

A five-spout ladle, designed to hold 1500 pounds, pours from either side.

Pete—
I believe we should order a couple new ladles now! See me!
B.K.



82" diameter ladle having 50,000 pounds metal capacity and built to steel mill specifications.



Obround mixing ladle of 36,000 pounds metal capacity.

Ask for CATALOG P-152-A

MODERN 2000 pound cylindrical, covered, distributing ladle with special bail. Tilted by motor or hand wheel.

Special inoculation ladle on transfer car. Ladle bowl is detachable.

MODERN

MODERN EQUIPMENT COMPANY

PORT WASHINGTON, WISCONSIN

Circle No. 147, Page 131-132

the editor's report

by Jack Schaum

■ **Modern Castings extends winning streak to four in a row.** Yes the magazine received its fourth successive National Safety Council Public Interest Award. This 1958 Award adds a third bronze star to the plaque pictured here. Again Modern Castings was the only magazine in the metalcastings industry to be so honored. Making foundrymen more safety conscious by means of editorial material has been reflected in the 20 per cent decrease in accident frequency rate among foundries during the past year.

Particular thanks are extended to the principle sources of Modern Castings' safety material—the AFS Safety Committee and H. J. Weber, AFS Director of Safety, Hygiene and Air Pollution Control.

■ **No lost time accidents** in the pattern shop of Texas Foundries, Inc., Lufkin, Texas, for the 4693 days preceding March 18 . . . and still headed for infinity. If you can top this 13 year record let me know.

■ **L. H. Durdin,** past president of AFS, pointed out in a recent talk that "50 metalworking industry groups spend an average of $1200 on research for every $25,000 of sales; yet the **metalcasting industry group spends only $1 on research** for the same gross sales." With this obvious imbalance our metalcasting industry can't help but lose ground to competitive fabricating processes. Foundrymen must face this challenge with a more realistic attitude toward plowing-back profit into research if they hope to survive in our competitive economy.

■ **Completely air setting binders** requiring no heating will soon be commercially available. Castings can be poured three hours after core or mold has been made.

NATIONAL SAFETY AWARD

■ **New technique saves 50 per cent** of the Mg formerly lost when making ductile iron. Magnesium containing alloy is placed in a can which is held in an inverted crucible. Crucible is attached to a refractory plunger rod running through a heavy lid which covers the ladle when crucible is plunged to bottom of melt. This confines reactions in the melt so violent oxidation at surface is held to a minimum.

■ **To back up their story on dust collecting** appearing in this issue of MODERN CASTINGS, Wheelabrator Corp., Mishawaka, Ind., finds that they are collecting four tons of dust per week emitted from their two 2-ton electric-arc furnaces. This is over one per cent of the 250 tons of steel scrap melted during the week. Imagine the sweeping, shoveling and coughing that this four tons of dust would account for if left to wander at its own discretion instead of being collected at its source of emission. For a better working climate remember the need for getting the DUST out of inDUSTry.

Published by American Foundrymen's Society, Golf & Wolf Roads, Des Plaines, Ill.

VAnderbilt 4-0181

WM. W. MALONEY, *General Manager*

Editorial Staff

JACK H. SCHAUM, *Editor*
PAUL R. FOGHT, *Managing Editor*
GEORGE A. MOTT, *News Editor*
KEITH L. POTTER, *Production Editor*
MALCOLM SMITH, *Art Director*

Contributing Editors

S. C. MASSARI, *Metallurgical*
H. J. WEBER, *Safety, Hygiene, and Air Pollution Control*
R. E. BETTERLEY, *Educational*

Business Staff

J. M. ECKERT, *Advertising Manager*
VIRGINIA SUTTERBY, *Advertising Production Manager*
ELAINE E. WALTERS, *Readers Service*

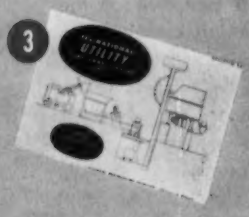
District Managers

WM. I. ENGLEHART—Cleveland
14805 Detroit Ave.
ACademy 6-2423
JAMES C. KURZ—Midwest
Golf & Wolf Rds., Des Plaines, Ill.
VAnderbilt 4-0181
R. E. MCLOUGHLIN—New York
205 E. 42nd St., Suite 318
LExington 2-7711
JOHN ASHCRAFT—European
67 Ave. des Champs Elysees
Paris 8, France

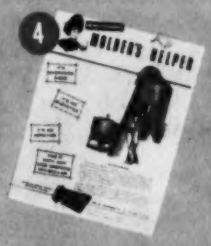
15 WAYS TO SAVE MONEY AND TIME IN THE FOUNDRY

15 NATIONAL BULLETINS describe the most complete line of foundry equipment of its type available *anywhere* . . . to help you make better and more salable castings through:

JOB-TAILORED MATERIALS HANDLING SYSTEMS



"UTILITY" UNIT



MOLDER'S HELPER

AIR CONVEYOR SYSTEM

DATA BOOK FOR ENGINEERS

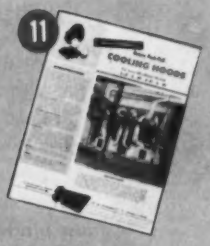
PROGRESSIVE MECHANIZATION

TIME SAVING MIX-MULLER AUXILIARIES

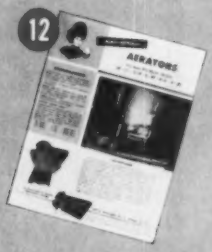
MAINTENANCE MANUAL

BUCKET LOADERS

SCREEN-MASTER



COOLING HOODS



AERATORS

FOUNDRY-ENGINEERED SYSTEMS

SAND RECLAMATION

SHELL MOLDING

DUST COLLECTORS

Circle No. 148, Page 131-132

SEND FOR LITERATURE

See opposite page for check list.

Just fill in and mail to . . .

NATIONAL ENGINEERING COMPANY
630 Machinery Hall Bldg.
Chicago 6, Illinois

Build an idea-file for improvement and profit. The post-free cards on *the last* page will bring more information on these new . . .

products and processes

SPRUE CUTTER . . . features seal at junction of post and cup. Adjustable to variety of cope heights. All parts replaceable. *Meldau Foundry Tool Co.*
For Manufacturer's Information Circle No. 1, Page 131-132

PORTABLE SANDBLAST . . . for use with any tank-type air compressor weighs 12 lb, has 12-qt abrasive capacity. *Malray Products, Inc.*
For Manufacturer's Information Circle No. 2, Page 131-132

DUCTILE BY PLUNGE . . . newest technique for producing ductile iron is plunging a refractory basket containing magnesium additive into a ladle of iron. Method is said to eliminate flame and smoke, lower treating cost and produce cleaner iron. Package designed for method contains weight of alloy needed for treatment of specific ladle size. *Ohio Ferro-Alloys Corp.*
For Manufacturer's Information Circle No. 3, Page 131-132

CO_2 SHELL MOLDS . . . combines close-tolerance aspects of shell molding with time, labor and equipment saving features of CO_2 process. *National Cylinder Gas Co.*
For Manufacturer's Information Circle No. 4, Page 131-132

WATERLESS MOLDING SAND . . . producing high-precision castings is possible with use of new sand binder. Dry binder is used with mix of 120 to 190 gfn sand, oil and a catalyst. Principal advantages are said to be reduction in gas on pour-off and use of finer sands, principal disadvantage is said to be higher initial cost of low clay content sand used. *Archer-Daniels-Midland Co., Federal Foundry Supply Div.*
For Manufacturer's Information Circle No. 5, Page 131-132

SCRAP HANDLER . . . attachment for tractor shovel moves 1200-lb loads of bales, turnings or scrap. *Yale & Towne Mfg. Co.*
For Manufacturer's Information Circle No. 6, Page 131-132

MOLDING MACHINE . . . features squeeze on standard 80 psi line pressure with 12-in. pattern draw and 12-1/2-in. squeeze stroke. *SPO Inc.*
For Manufacturer's Information Circle No. 7, Page 131-132

DIAPHRAGM MOLDING MACHINES . . . feature high speed, automatic operation. Cycles in less than 12 sec. Offers hydraulic squeeze action with choice of flexible diaphragm or rigid squeeze heads. Line includes three machines for shops. *Osborn Mfg. Co.*
For Manufacturer's Information Circle No. 8, Page 131-132

WEIGHT-SHIFTER . . . automatically places mold weights and later removes weights from poured-off molds. Handles up to 400 molds per hour. *Planet Corp.*
For Manufacturer's Information Circle No. 9, Page 131-132

"WET WATER" . . . may be produced in small volumes required for mulling, sand conditioning, core washes, other foundry operations through use of new concentrated compound. *Deynor Corp.*
For Manufacturer's Information Circle No. 10, Page 131-132

FLASK-RAPPER . . . is a pneumatic vibrator with only one moving part. Use for rapid shake-out and general knock-out work. *National Air Vibrator Co.*
For Manufacturer's Information Circle No. 11, Page 131-132

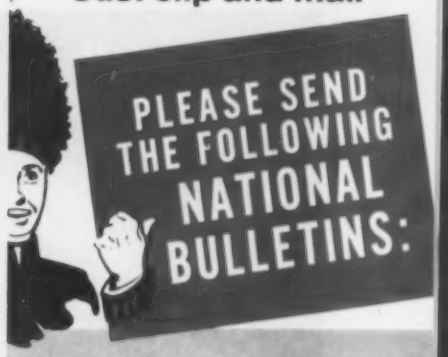
RESIN CORE BINDER . . . is recommended for malleable, light-weight gray iron, aluminum, magnesium, brass, bronze castings. Formula UP-15 was developed for conventional or dielectric-baked cores. *Archer-Daniels-Midland Co., Federal Foundry Supply Div.*
For Manufacturer's Information Circle No. 12, Page 131-132

ALUMINUM ALLOY . . . claiming unique mechanical characteristics is called "Adaptaloy." Properties include exceptionally high elongation, impact strength and malleability. *Federated Metals Div., American Smelting and Refining Co.*
For Manufacturer's Information Circle No. 13, Page 131-132

TWIN-TABLE CLEANING ROOM . . . for cleaning individual castings to five tons throws 100,000 lb of abrasive hourly. One work table is loaded while second is revolving inside blast cabinet. *Pangborn Corp.*
For Manufacturer's Information Circle No. 14, Page 131-132

Continued on page 8

Just clip and mail



1 F SERIES MIX-MULLER ☐
2 SIMPSON PORTO-MULLER ☐
3 "UTILITY" UNIT ☐
4 MOLDER'S HELPER ☐
5 AIR CONVEYOR SYSTEM ☐
6 DATA BOOK FOR ENGINEERS ☐
7 PROGRESSIVE MECHANIZATION ☐
8 MAINTENANCE MANUAL ☐
9 BUCKET LOADERS ☐
10 SCREEN-MASTER ☐
11 COOLING HOODS ☐
12 AERATORS ☐
13 SAND RECLAMATION ☐
14 SHELL MOLDING ☐
15 DUST COLLECTORS ☐

NATIONAL ENGINEERING COMPANY
630 Machinery Hall Bldg.
Chicago 6, Illinois

Mail literature to:

Company.....

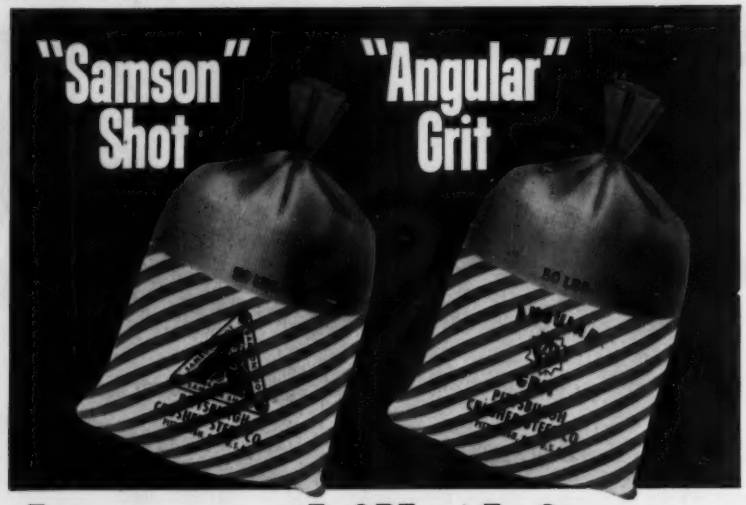
Address.....

City.....**Zone**....**State**.....

Your Name.....

Circle No. 148, Page 131-132

FREE



better chilled iron abrasives..and why

We have made metal abrasives since 1888. We pioneered their use in place of silica sand for blast-cleaning. We have "grown up" with their expanding use, acquiring unequalled know-how and experience along the way. *No other maker of metal abrasives has an equal experience record.*

Since 1937 we have carried on a continuous program of research for improvement of metal abrasives with one of America's foremost metals research organizations. *No other metal abrasives maker has an equal record of research.*

Ours is the only plant in America using the HOT BLAST MELTING process for production of metal abrasives; this, plus fully automated processing, provides the complete quality control that assures uniformity of chemistry, structure and hardness from one lot to another —assures the user of obtaining the same high performance from every shipment of Samson Shot and Angular Grit.

Experience, research, superior manufacturing facilities make these better chilled iron abrasives cheaper to use than those made to sell at a price.

LEADERS in development of PREMIUM-TYPE ABRASIVES

The two best known names in premium abrasives were developments of two of our subsidiaries. MALLEABRASIVE, the first malleablized type of metal abrasive ever produced, set the pace for development of all other makes of premium abrasives. TRU-STEEL Shot was the first high-carbon all steel shot produced to meet demand for this specialized type of abrasive.

One of these products may do your blast-cleaning job better, and at lower cost. Write us for full information.

PITTSBURGH CRUSHED STEEL CO.

Arsenal Sta., Pittsburgh 1, Pa.

Subsidiaries: The Globe Steel Abrasive Co., Mansfield, Ohio (Malleabrasive)
Steel Shot Producers, Inc., Arsenal Sta., Pittsburgh (Tru-Steel)

Circle No. 150, Page 131-132

products and processes

Continued from page 7

COPPER MELTING LINE . . . is designed to continuously melt and deliver a constant, uniform flow of oxide-free copper at constant temperature. *Lindberg Engineering Co.*

For Manufacturer's Information Circle No. 15, Page 131-132

CENTRIFUGAL CASTING MACHINE . . . is designed for automatic production of cast iron cylinder liners. Production rate is 45 castings per hour. *Centrifugal Casting Machine Co.*

For Manufacturer's Information Circle No. 16, Page 131-132

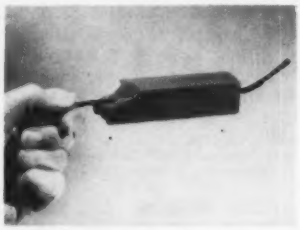
PERMEABILITY STANDARD . . . contains sapphire orifice enabling original calibration to be maintained indefinitely. Standard is used to check permeability meter. *Harry W. Dietert Co.*

For Manufacturer's Information Circle No. 17, Page 131-132

RARE-EARTH ALLOY . . . is designed for sand cast missile parts. Composition is 3.2 per cent rare-earth metal, 0.6 per cent zirconium, balance magnesium. *Dow Chemical Co.*

For Manufacturer's Information Circle No. 18, Page 131-132

CORE WIRES . . made of cord-like, resin-impregnated fiber glass break up during shakeout, eliminating resorting and reforming. Cord forms to any con-



tour, will not deform and will not weld to casting. *Archer-Daniels-Midland Co.*

For Manufacturer's Information Circle No. 19, Page 131-132

OPTICAL PYROMETER . . . combines all mechanical and optical parts in telescope-type housing. *Epic, Inc.*

For Manufacturer's Information Circle No. 20, Page 131-132

LOW-PRICED TIG WELDER . . . produces quality welds on non-ferrous metals. Kit containing all equipment for tungsten inert-gas welding in the 100 amp range or below is priced below $100. *Air Reduction Sales Co.*

For Manufacturer's Information Circle No. 21, Page 131-132

HAND TRUCK . . . designed for conveying and pouring crucibles of molten metal enables one man to do most jobs where two-man shanks are normally required. *Morehouse Machine Co.*

For Manufacturer's Information Circle No. 22, Page 131-132

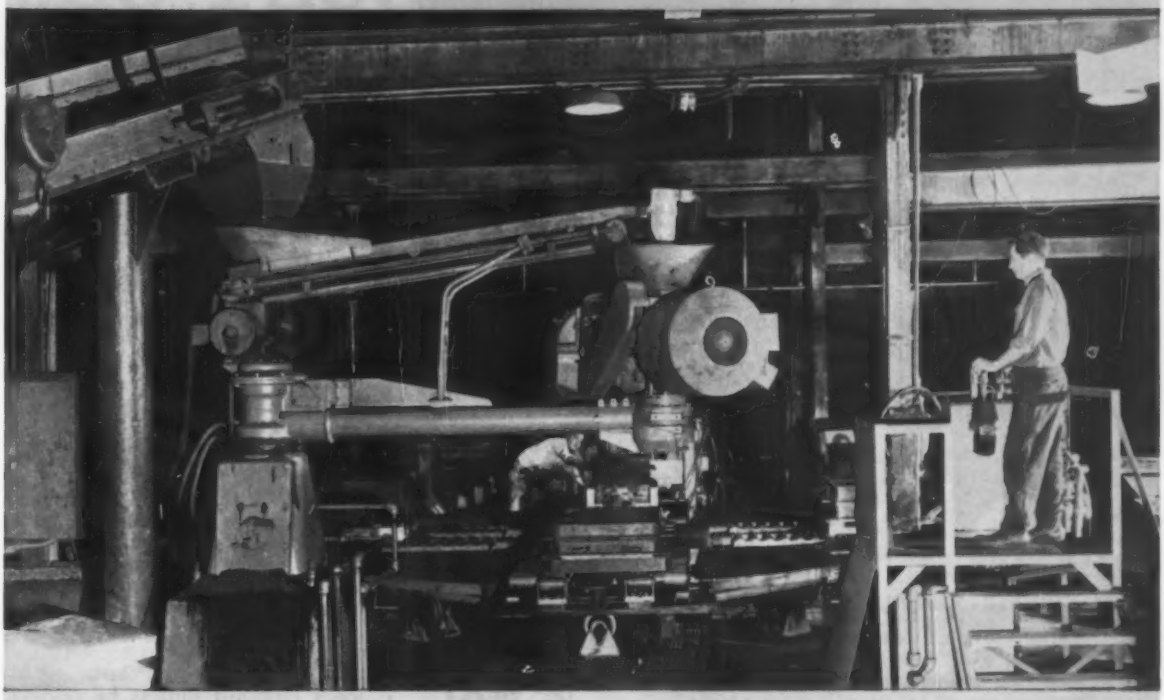
EPOXY PLANKS . . . to duplicate desirable qualities of natural mahogany for patternmaking is available 1 in. x

Continued on page 10

GO OUT AND BUY CASTINGS?

BUILD A NEW PLANT?

MECHANIZE EXISTING PLANT?



BROWN & SHARPE'S CHOICE...

Inadequate foundry facilities left Brown & Sharpe, one of the world's outstanding machine tool producers, with only three courses. They would have to go out and buy castings from a jobbing foundry, build a new foundry, or completely revitalize their existing set-up through mechanization.

A staff of engineers studied the problem thoroughly. Because of the difficulties involved in developing new casting sources for their quantity and type of castings, a new foundry looked like the only way out, yet, management knew that the huge investment required would create a real overhead problem.

Then, the engineers investigated the tremendous flexibility and low cost of Hydra-Slinger mechanization. Mechanization of the existing foundry became the only logical course to follow. Now, Brown & Sharpe's largest molds—weighing up to five tons—are made on a Hydra-Slinger "Figure 9" Loop Conveyor Unit. Smaller work is handled on a Hydra-Slinger Roto-Mold Unit, served by a B&P Rol-A-Draw. An added assurance of quality and production is provided by a Model "60A" Speedmullor, which prepares the foundry's molding sand.

Brown & Sharpe's mechanization has paid off.

1. They avoided the huge investment required by a new plant.
2. Existing space and facilities have been utilized to provide all of the production needed.
3. The company has been able to obtain cost and control advantages by producing its own castings.

B&P mechanization can pay off in other ways, too. Write now!

BEARDSLEY & PIPER

Div. Pettibone Mulliken Corp.
2424 N. Cicero Avenue
Chicago 39, Illinois

B&P

Circle No. 131, Page 131-132

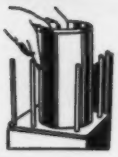
IT'S A FACT:

ALLIS-CHALMERS LIFT TRUCKS SAVE YOU MORE... MAKE YOU MORE!

HERE'S PROOF... When it comes to sustained high production over the years — ability to stay on the job and out of the shop — Allis-Chalmers trucks have it! As these owners happily admit:

"They're tougher and require less maintenance," says the mechanic at a Wisconsin foundry. "I particularly like the overhead valves and wet cylinder liners — makes our job a lot easier."

Reason: Wet cylinder liners are easily replaced — no need to rebore.

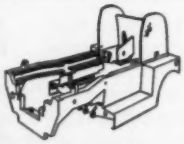


"Maintenance costs are one-third less than with lift trucks previously used" reports a Michigan factory. "We used to replace an engine a year," says the vice-president. Haven't replaced any in our Allis-Chalmers trucks."

Reason: The heavy-duty, industrial engine is the strongest and most rugged used in a fork truck.

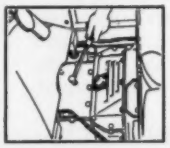
Downtime, None — That's the report of a Florida cement block manufacturer. His 4,000-lb lift truck has operated steadily for more than three years.

Reason: Rugged construction of Allis-Chalmers trucks which is typified by automotive-type frames.



"They're certainly accessible to work on," says the mechanic at a Missouri factory, "— although we have not had too much maintenance and no parts replaced at all so far."

Reason: A good example of accessibility: only 30 minutes is required to change a clutch.



Let your material handling dealer show you additional production and maintenance figures for Allis-Chalmers lift trucks that make their superiority a *fact*. Allis-Chalmers, Milwaukee 1, Wisconsin.

ALLIS-CHALMERS

BH-1058

Plan to stay ahead... MODERNIZE!

Circle No. 152, Page 131-132

products and processes

Continued from page 8

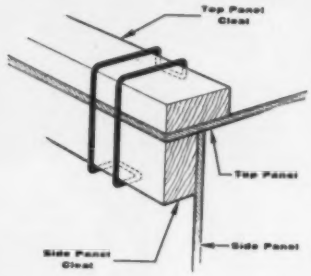
12 in. x 60 in. Material weighs 30 lb per cut ft, is said to be easily carved or machined. *Furane Plastics Inc.*

For Manufacturer's Information Circle No. 23, Page 131-132

NYLON CORE VENTS . . . are said to eliminate sand sticking, fit shape of box, outlast metal vents 3 to 1. *Ronson Industries.*

For Manufacturer's Information Circle No. 24, Page 131-132

KLIMP FASTENERS . . are used to assemble flasks and boxes made up of interchangeable panels. Fastener holds



like clamp, is attached and removed quickly, and can be reused many times. *Navan Products Inc.*

For Manufacturer's Information Circle No. 25, Page 131-132

FINISHING ABRASIVE . . . produces unique finish on zinc and aluminum die castings. Wheels of nylon web impregnated with abrasive mineral replace polishing compounds in some operations. *Minnesota Mining and Mfg. Co.*

For Manufacturer's Information Circle No. 26, Page 131-132

CONTOUR GAGE . . . checks and inspects contoured surfaces by precision measuring. Eliminates intricate set-ups and layouts. *Turbotronics Corp.*

For Manufacturer's Information Circle No. 27, Page 131-132

PORTABLE FINISHING BARREL . . . said to be ideal for laboratories and job shops has 1/2-cu ft capacity. *Almco, Queen Products Div., King-Seeley Corp.*

For Manufacturer's Information Circle No. 28, Page 131-132

PORTABLE AIR-OPERATED HOISTS . . are designed to be easily moved and installed by one man. *Ingersoll-Rand Co.*

For Manufacturer's Information Circle No. 29, Page 131-132

MAGNETIC INSPECTION UNIT . . for detecting surface and subsurface defects in ferrous parts is said to be only unit that demagnetizes part after inspection. Portable, weighs 150 lb. *Ferro Machine & Tool Corp.*

For Manufacturer's Information Circle No. 30, Page 131-132

INVESTMENT CASTING SHAKEOUT . . . can be accomplished with air-operated riveter. *Ingersoll Rand Co.*

For Manufacturer's Information Circle No. 31, Page 131-132

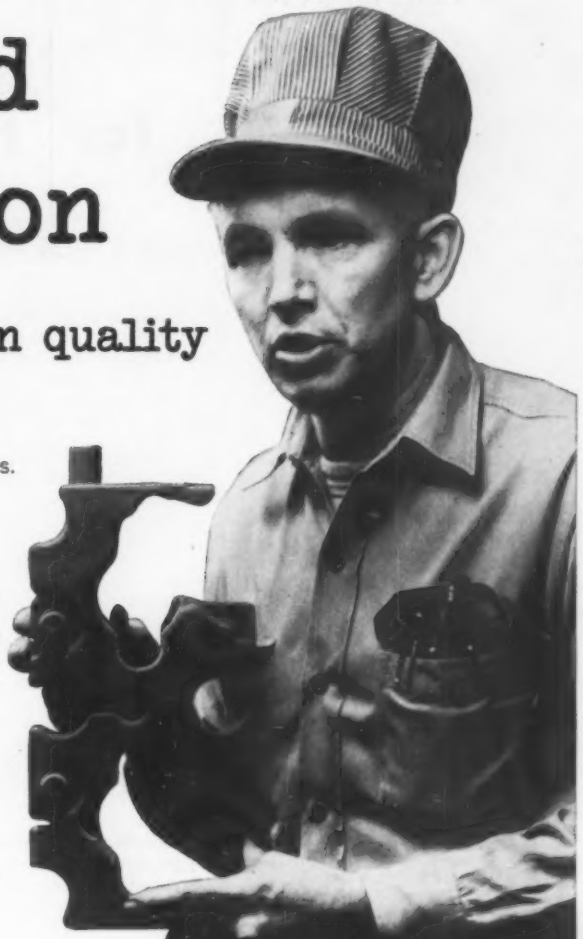
Report from Al Floyd, Assistant Core Superintendent, North Core Room, Golden Foundry Company, Inc., Columbus, Indiana:

We bucked the recession

by holding the line on quality

"The boss, George Stofer, and I talked it over many times. Could we beat the price squeeze by buying cheaper? We decided to stand firm on quality cores."

"This meant the continued use of high quality **LINOIL.** If we went to a cheap oil for intricate water-jacket cores like these, our scrap would go sky high. We like the added insurance of **LINOIL** . . . it helps hold our core scrap on heads and jackets to 2.06%. We think that's good!" "Our customers agree. That's another reason why Golden Foundry poured regularly throughout the slow-down period."



"Using regular lake bank sand, here's our mixture for these cores:

1% LINOIL
¾% Cereal
2% Iron Oxide
½% Silica
½% GREEN BOND Bentonite
2% Moisture

We bake them at 425° for 2½ hours."

Archer QUALITY

Archer-Daniels-Midland company
FEDERAL FOUNDRY SUPPLY DIVISION
2191 West 110th Street • Cleveland 2, Ohio

Circle No. 153, Page 131-132

NARCAL 70B

THE ONE MODERN HIGH ALUMINA PLASTIC REFRACTORY

for ALL your requirements!

- Electric Furnace Roofs or Center Sections
- Crucible Furnaces
- Runners
- Spouts
- Ladles (all types)

JOINTLESS CONSTRUCTION

EASE OF INSTALLATION

LONG-LASTING SERVICE

Furnished in

- 100 lb. Easy-to-Handle Cartons
- Conveniently Sized 2" Slices
- Air or Hand Ram Consistency
- Polyethylene Envelopes for Safe Storage

NORTH AMERICAN REFRACTORIES CO.
General Offices, Cleveland 14, Ohio
DISTRICT SALES OFFICES:
New York 7, N. Y.
Philadelphia 2, Pa.
Boston 10, Mass.
Buffalo 3, N. Y.
Pittsburgh 22, Pa.
Detroit 2, Mich.
Chicago 5, Ill.
Cincinnati 2, Ohio
Los Angeles, Calif.
NARCO
NORTH AMERICAN REFRACTORIES, LTD.
Hamilton, Ontario

Circle No. 154, Page 131-132

Build an idea-file for improvement and profit. The post-free cards *on the last page* will bring more information . . .

for the asking

Pinholes or inclusions . . . is the title of newsletter which discusses inspection, causes, inclusions, improperly cleaned ladles and other factors causing these faults. *American Colloid Co.*
Circle No. 61, Page 131-132

Welders' vest-pocket guide . . . describes and illustrates in 60 pp four essentials of proper welding procedures, types of joints and welding positions. *Hobart Bros. Co.*
Circle No. 62, Page 131-132

Radiography . . . in modern industry handbook, 140 pp, well illustrated, for engineer or student. *X-Ray Div., Eastman Kodak Co.*
Circle No. 63, Page 131-132

Conversion factor . . . wall-chart reference table for engineers and executives to speed up location of factors used daily. *Precision Equipment Co.*
Circle No. 64, Page 131-132

Temperature conversion . . . chart, wallet-size, with easy-to-read tables of Fahrenheit and Centigrade temperature equivalents. *Moeller Instrument Co.*
Circle No. 65, Page 131-132

Microscopic photography . . . data book of the elementary photomicrographic technique available in a revised edition. *Eastman Kodak Co.*
Circle No. 66, Page 131-132

Inoculants . . . for cast and ductile iron described in booklets which use pictures, graphs and tables to show advantages. *Electro Metallurgical Co., Div. Union Carbide Corp.*
Circle No. 67, Page 131-132

Birth of gray iron castings . . . related in technical, colorful, 20-p book. *Pittsburgh Coke & Chemical Co.*
Circle No. 68, Page 131-132

Machining gray and nodular iron . . . 22-p booklet covers machining properties of cast iron. *Hamilton Foundry & Machine Co.*
Circle No. 69, Page 131-132

Technical data . . . catalog free. Revised listing of pocket-size books covering every field of engineering. *Lefax Publishers.*
Circle No. 70, Page 131-132

Carbon sand . . . a new molding material composed of particles of hard carbon is described and compared with other molding sands. *J. S. McCormick Co.*
Circle No. 71, Page 131-132

Shell casting . . . featured in monthly publication. *Cooper Alloy Corp.*
Circle No. 72, Page 131-132

Manufactured graphite . . . technical data offered in handbook. *National Carbon Co., Div. Union Carbide Corp.*
Circle No. 73, Page 131-132

Foundry practice . . . bulletin includes four technical articles dealing with: aluminum rotor castings, copper-tin alloys, pressure and exothermic feeding of iron castings and heat treatment. *Foundry Services, Inc.*
Circle No. 74, Page 131-132

Molybdenum . . . its role in steel castings, thoroughly discussed in 36-p booklet prepared at Case Institute of Technology for Steel Founders Society. *Climax Molybdenum Co.*
Circle No. 75, Page 131-132

Wall chart . . . lists decimal equivalents of fractions of an inch—1/64 to 1 in. Use the Reader Service card, last page, for your free chart. *Ohio Seamless Tube Div., Copperweld Steel Co.*
Circle No. 76, Page 131-132

Technical translations . . . of Russian and other technical material are included in new government publication. For more information about this service, use circle number below. *Office of Technical Services, United States Department of Commerce.*
Circle No. 77, Page 131-132

Iron and steel scrap . . . fact sheet in folder form answers many questions about scrap. *Institute of Scrap Iron & Steel Inc., Committee on Bankability.*
Circle No. 78, Page 131-132

Japanese foundry equipment . . . well illustrated and described in catalog. Written in English. *Kubota Seisakusho, Ltd.*
Circle No. 79, Page 131-132

Machining manual . . . 22-pp, contains guide for machine feeds and speed, includes quantity-weight slide rule calcu-

Continued on page 14

Tough, Durable Cores

every time with

Foundrez Resin Core Binders

Photos taken at Florence Pipe Foundry & Machine Co., Florence, N. J.

Volume production of heavy castings demands that the cores used by Florence Pipe Foundry & Machine Company stand up under rough handling. Florence secures the high tensile strength and hardness needed in these cores by using RCI FOUNDREZ 7100 series resin binders in their molding sand.

These water dispersible phenol-formaldehyde core binders are especially formulated for use where baking time is at a premium. In addition they possess higher hot strength and slower collapsibility than either core oils or urea-formaldehyde binders.

These resins are used in conventional core sand mixtures containing cereal binders and water. Only half as much FOUNDREZ as regular core oil is required to produce equivalent core handleability. Reichhold's FOUNDREZ 7100 series includes:

Foundrez 7101 — a high solids binder compounded for foundries where core gas is a problem. Extremely effective in producing cores with high strength and hardness.

Foundrez 7102 — formulated for very rapid baking schedules, this binder provides excellent green strength with a minimum of cereal binder.

Foundrez 7103 — features easy collapsibility and a low viscosity which permits ready mixing.

Foundrez 7104 — combines a high degree of stability with high tensile strength. Resultant cores are extremely moisture resistant — may be stored for long periods without fear of moisture pickup.

For complete technical data on the FOUNDREZ 7100 line write Reichhold — ask for Bulletin F-1-R.

Creative Chemistry . . .
Your Partner in Progress

RCI

REICHHOLD

FOUNDRY PRODUCTS

FOUNDREZ—Synthetic Resin Binders

COROVIT—Self-curing Binders • coRCIment—Core Oils

REICHHOLD CHEMICALS, INC., RCI BUILDING, WHITE PLAINS, N.Y.

Circle No. 155, Page 131-132

"I vote for the H-25 PAYLOADER®"

"The new bucket breakout is very effective because it takes a bite that amounts to something," says Orlin Holm, Maintenance Foreman of Baker Manufacturing Co., Grey Iron Foundry, Evansville, Wisconsin.

"It also gives low load-carry position for better driver vision and faster, safer operation. Power-steering is also a great help in a crowded foundry such as ours. It gives the driver quicker, easier control and if a wheel hits something it doesn't throw him."

Baker's Model H-25 "PAYLOADER" unit is used both day and night. Daytimes it charges furnaces with iron, coke and lime and hauls out burned sand. At night it scoops up the sand from the pouring floor and feeds it to the cleaning-aerating unit.

No other tractor-shovel can give you so much carry capacity (2,500 lbs.) on so short a turning radius (6 ft.). Its power-shift transmission with 2 speed ranges each direction, torque converter drive and power-steer make it the easiest, safest operating machine for the job. Power transfer differential — another exclusive in its class — gives the Model H-25 better traction on loose or slippery footing.

Your Hough Distributor is ready with further facts about the new Model H-25.

HOUGH®

THE FRANK G. HOUGH CO.
LIBERTYVILLE, ILLINOIS
SUBSIDIARY — INTERNATIONAL HARVESTER COMPANY

THE FRANK G. HOUGH CO.
711 Sunnyside Ave.
Libertyville, Ill.

Send Model H-25 "PAYLOADER" data

Name _____
Title _____
Company _____
Address _____
City _____ State _____

7-A-2

Circle No. 156, Page 131-132

for the asking

Continued from page 12

lator, and other basic information. *Kaiser Aluminum & Chemical Sales, Inc.*
Circle No. 80, Page 131-132

Wall chart . . . giving designations and specifications for non-ferrous alloys. To get yours, circle number below on Reader Service card, last page of this issue. *Non-Ferrous Founders' Society.*
Circle No. 81, Page 131-132

Pearlitic malleable handbook . . . 76 pp, serves as ready reference on latest information and data. A copy is yours if you are a design engineer or can use this engineering data in your work. *Malleable Research and Development Foundation.*
Circle No. 82, Page 131-132

Core processes . . . reprint, six pp, discusses four major core making processes with a comparison of advantages and disadvantages of each. *Archer-Daniels-Midland Co.*
Circle No. 83, Page 131-132

Training courses . . . pertinent to every type of metalcasting work are offered by the AFS Training and Research Institute. For free brochure covering all courses offered, circle number below on Reader Service card, last page. *American Foundrymen's Society.*
Circle No. 84, Page 131-132

Wood and metal pattern . . . development and production fully described in 12-p booklet. *Motor Patterns Co.*
Circle No. 85, Page 131-132

Index . . . to 1958 Modern Castings. Lists the subjects, titles and the authors of all important information published during last year. *American Foundrymen's Society.*
Circle No. 86, Page 131-132

Materials handling . . . equipment descriptions, data and specifications presented in new condensed catalog No. 591. *Syntron Co.*
Circle No. 87, Page 131-132

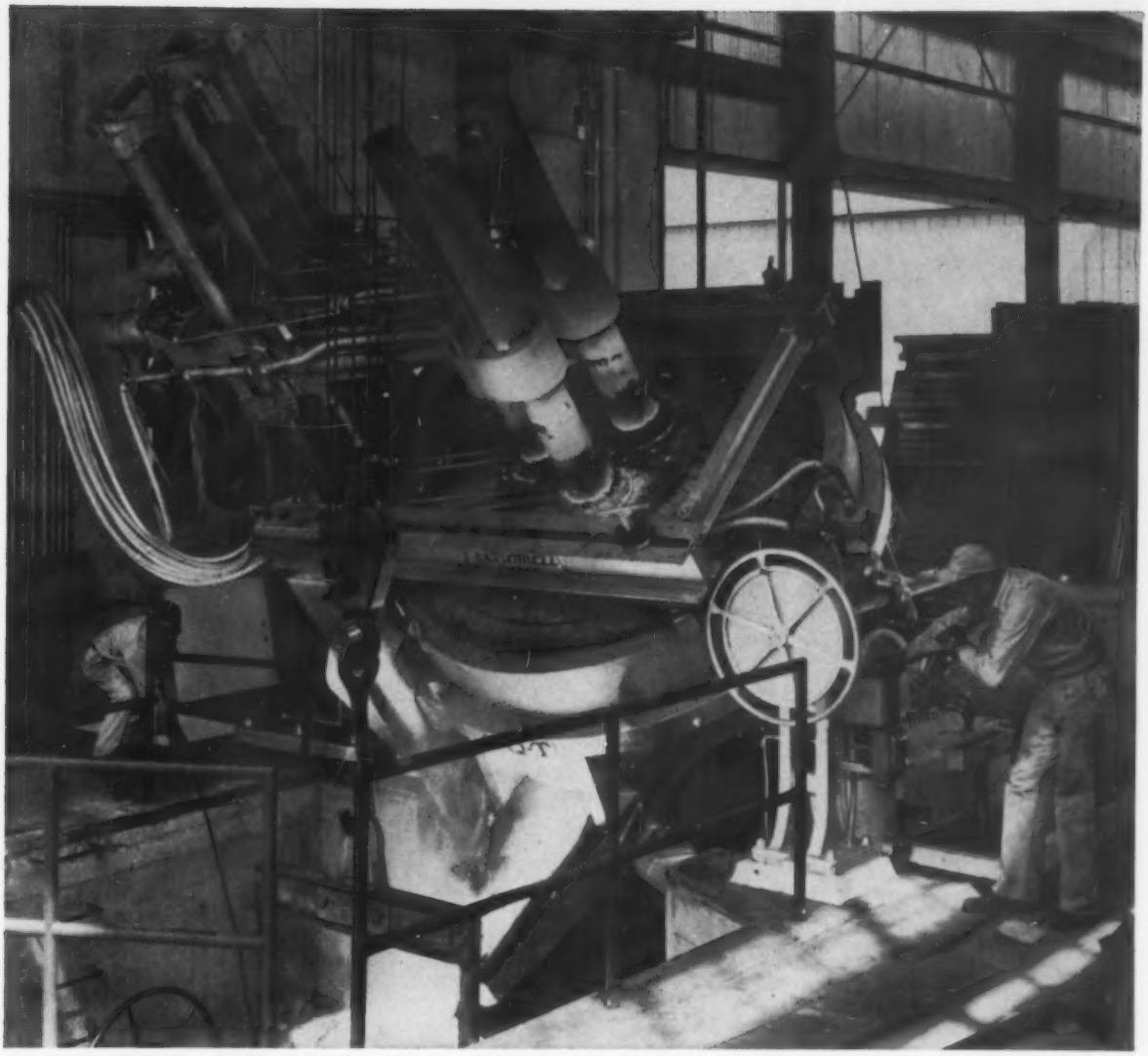
Dry sand reclamation . . . unit explained with cost saving advantages described in brochure. Use the circle number below. *Beardsley & Piper Co.*
Circle No. 88, Page 131-132

Electric arc welding . . . by process that cuts and gouges metal and then blows away the melted metal with high velocity jet of compressed air. Process featured in 10-p case history bulletin. *Arcair Co.*
Circle No. 89, Page 131-132

Pouring practice . . . for bottom-pour ladle systems discussed in well-illustrated brochure. *Vesuvius Crucible Co.*
Circle No. 90, Page 131-132

Spectroscope . . . for qualitative and quantitative spectrochemical analysis is fully explained in brochure which is yours simply by circling this number

Continued on page 17



LECTROMELT Melts–Taps–Recharges Fast ...GIVES MAXIMUM OUTPUT

Lectromelt furnaces are powered to speed up melting greatly. You tilt and pour smoothly and quickly... and the Lectromelt top-charging arrangement is planned to minimize your down-time between heats.

In every detail, Lectromelt furnaces are designed to give you efficient melting for years to come. If you're planning new capacity, you'll find it pays to contact Lectromelt—world's most experienced builder of electric furnaces. Lectromelt Furnace Division, McGraw-Edison Company, 316 32nd Street, Pittsburgh 30, Pennsylvania.

FOR THE MOST EFFICIENT MELTING–Lectromelt®

McGRAW EDISON

CANADA: Wild-Barfield Electric Furnaces, Ltd., Toronto... ITALY: Forni Stein, Genova... ENGLAND: G.W.B. Furnaces Limited, Dudley, Worcs.... GERMANY: Demag-Elektrometallurgie, GmbH, Duisburg ... SPAIN: General Electrica Espanola, Bilboa... FRANCE: Stein et Roubaix, Paris... BELGIUM: S. A. Stein & Roubaix, Bressoux-Liege... JAPAN: Daido Steel Co., Ltd., Nagoya

Circle No. 157, Page 131-132

THE VEXING PUZZLE OF THE REJECTED ROTORS

Another costly mystery solved–by the man from Kaiser Aluminum

THE PERPLEXING FACTS. A manufacturer of electric motors brought Kaiser Aluminum a perplexing problem. He was having difficulty casting sound rotors. His main problem was porosity which resulted in many rejected units.

HOW THE CASE WAS SOLVED. When the man from Kaiser Aluminum reviewed the casting process, he recommended a correction in fluxing techniques—and suggested that the casting dies be redesigned to improve gating and venting. Outcome: the porosity disappeared and the matter was closed.

WE LOVE A MYSTERY. This is one of many actual cases solved by Kaiser Aluminum working with a customer. Perhaps *you* have a mystery one of our technical engineers might help solve? He's ready to give you expert advice on any casting problem—including mold and die design, heat treatment, finishing, fluxing, metal transfer.

FULL ALLOY AVAILABILITIES. Kaiser Aluminum can supply you *fast* with a wide selection of casting alloys to suit any engineering requirement—from general purpose alloys to high purity alloys having good properties at elevated temperatures.

FOR PIG AND INGOT with a free sleuthing bonus, call your nearest Kaiser Aluminum sales office now. Or write to: Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland 12, California.

KAISER ALUMINUM
THE BRIGHT STAR OF METALS

See "MAVERICK" • Sunday Evenings, ABC-TV Network • Consult your local TV listing.

Circle No. 169, Page 131-132

for the asking

Continued from page 14

on the Reader Service card, last page. *Applied Research Laboratories.*
Circle No. 91, Page 131-132

Vancoram briquettes . . . for iron foundries detailed in leaflet. *Vanadium Corp. of America.*
Circle No. 92, Page 131-132

Wear plates . . . for tumble-type shot cleaning equipment detailed in fact sheets. *A.I.C. Engineering Co.*
Circle No. 93, Page 131-132

Foundry truck . . . interchanges bucket and forks without tools. Send for free folder. *Beardsley & Piper, Div. Pettibone Mulliken Corp.*
Circle No. 94, Page 131-132

Automatic saw sharpening . . . of band saw blades accomplished with attachment for saw sharpening machine. Send for bulletin. *Hamco Machines, Inc.*
Circle No. 95, Page 131-132

Shell molding . . . problems answered in brochure. Answers such questions as, "How to avoid casting fins in shell molding." *General Electric Co.*
Circle No. 96, Page 131-132

Microstructure . . . of gray iron castings illustrated in 12-p booklet showing micrographs of castings with from 31,500 to 63,000 psi. To obtain, use circle number. *Herbert A. Reese & Associates.*
Circle No. 97, Page 131-132

Welding . . . data book, 13 pp, offers guide for selecting proper welding alloy and welding procedure for specific jobs on every base metal. *Eutectic Welding Alloys Co. of Canada, Ltd.*
Circle No. 98, Page 131-132

Ductile iron . . . mechanical and physical properties listed in 28-p brochure. Industrial applications pointed out. *International Nickel Co.*
Circle No. 99, Page 131-132

Hydraulic cylinders . . . featuring new cushion adjustment covered in manufacturer's literature. *Miller Fluid Power Div., Flick-Reedy Corp.*
Circle No. 100, Page 131-132

Shell mold curing . . . accessory for curing tensile and transverse test specimens described in company literature. *Harry W. Dietert Co.*
Circle No. 101, Page 131-132

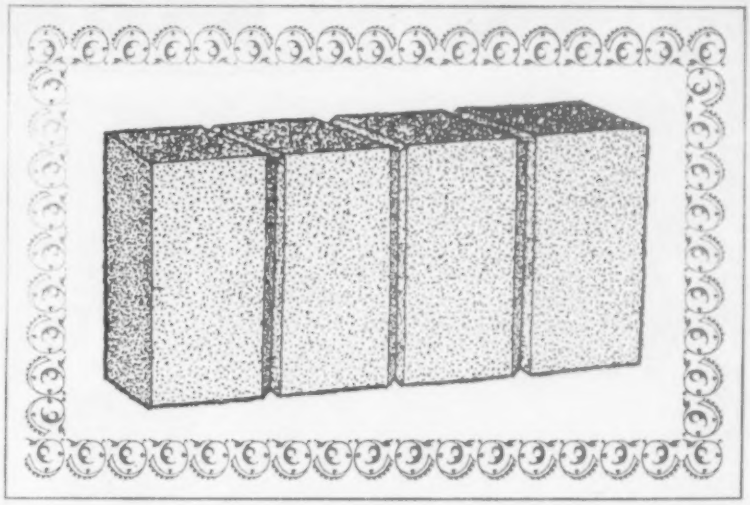
Welding torch . . . for consumable-electrode inert-gas metal-arc welding outlined in manufacturer's brochure. *Linde Co., Div. Union Carbide Corp.*
Circle No. 102, Page 131-132

Manganese alloys . . . leaflet discusses compositions and uses of ferromanganese and silicomanganese briquettes. *Vanadium Corp. of America.*
Circle No. 103, Page 131-132

Steelmaking . . . through use of oxygen in electric furnaces is subject of infor-

Continued on page 18

GUARANTEED
to give CLEANER IRON to all Gray Iron and Malleable Foundries



Famous **CORNELL CUPOLA FLUX** *is*

"often imitated but never equalled"

Once you use Famous Cornell Cupola Flux you'll see why foundrymen prefer it. This is the one scientifically designed product that greatly increases slag flow off and guarantees complete cleansing of coke (giving carbon constant). Many dollars are saved in cupola maintenance, too, since digging out is greatly reduced. In addition, Famous Cornell Cupola Flux insures less erosion of cupola lining as a vitreous protective surface is formed on brick or stone. Call a Cornell Engineer today or write for Bulletin 46-B.

Have you tried Famous Cornell Aluminum, Copper or Brass Flux?

Write for Bulletin 46-A.

FAMOUS CORNELL FLUXES

The CLEVELAND FLUX Company

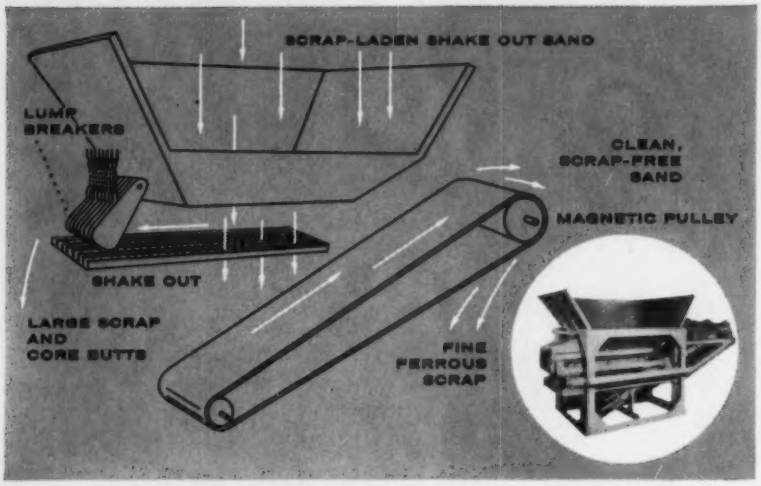
1026-40 MAIN AVENUE, N.W. • CLEVELAND 13, OHIO

Manufacturers of Iron, Semi-Steel, Malleable, Brass, Bronze, Aluminum and Ladle Fluxes—Since 1918

Circle No. 159, Page 131-132

SAND CONDITIONING TOPICS

PUBLISHED BY ROYER, MANUFACTURERS OF THE FOREMOST IN SAND CONDITIONING EQUIPMENT



Sand Contamination Drains Your Profits

Periodic business recessions in the foundry industry point up the need to eliminate waste and excessive hand labor—or sacrifice profits. In one area of foundry operation—sand contamination — important strides have been made in stopping the profit drainage.

Tramp iron damage usually occurs at the muller, conveyor belts, aerator or patterns. Patterns faced with contaminated sand produce poor casting finishes and high scrap loss. Probably the most efficient and economical way to remove contamination and produce clean sand is with a Royer Scrap Control Unit.

Referring to the drawing, shake out sand from the molding floor is dumped by front-end loader into the receiving hopper. Large scrap is riddled out by the Shake-Out and discharged at convenient wheelbarrow height for collection and removal.

Ferrous scrap small enough to pass through the grid openings of the Shake-Out is separated from the sand by a magnetic pulley at the upper end of the conveyor belt. Depending upon the degree of mechanization you employ, clean sand discharge may be made to a skip hoist feeding a muller, conveyor belt, or into the hopper of a Stationary Royer Separator and Blender for cooling, aeration and blending. We recommend discharge onto a heap for transporting by front-end loader to a Portable Royer Separator and Blender at the molding station for cooling, aerating and fluffing.

If tramp iron is the cause of any of your profit loss, we invite you to discuss your problem with the foundry-wise Royer agent serving your territory. He'll explain how a Royer Scrap Control Unit can pay for itself in less than two years, stop your profit drainage and improve the quality of your castings.

Your first step in stopping profit drainage caused by sand contamination is to mail the coupon for our latest Scrap Control Bulletin. We'll send it without obligation—plus the name of the agent who serves you.

ROYER FOUNDRY & MACHINE CO.

ROYER 155 PRINGLE STREET KINGSTON, PENNA.

Sand Contamination is cutting into our profits. Please rush me your Scrap Control Bulletin.

NAME_____

COMPANY_____

ADDRESS_____

CITY_____ ZONE_____ STATE_____

Circle No. 160, Page 131-132

for the asking

Continued from page 17

mation report discussing advantages of oxygen and listing techniques and equipment. *National Cylinder Gas, Div. Chemetron Corp.*

Circle No. 104, Page 131-132

Literature index . . . 24 pages, covers industrial instrumentation catalogs, specifications, technical bulletins, data sheets and magazine articles. *Minneapolis-Honeywell Regulator Co., Industrial Div.*

Circle No. 105, Page 131-132

Power-cutting switch . . . automatically cuts power supply when a hoist or crane approaches overload stage. Send for bulletin. *W. C. Dillon & Co.*

Circle No. 106, Page 131-132

Electric-furnace smelting . . . and subsequent refining of almost any type of iron ore described in 16-p brochure. Presents layout drawing of typical plant, and estimated capital and operating costs. *Koppers Co.*

Circle No. 107, Page 131-132

Chaplet selection chart . . . reportedly demonstrates quick and easy methods of determining size and number of chaplets required to support cores to obtain dimensionally accurate wall thicknesses. *Fanner Mfg. Co.*

Circle No. 108, Page 131-132

Front-end loaders . . . with up to 9000-lb carrying capacity and 1-3/4 cu yd bucket capacity outlined in folder. Also, grapple, fork lift, side boom and leaf loader attachments. *Frank G. Hough Co.*

Circle No. 109, Page 131-132

Refining and desulphurizing . . . cupola iron described in brochure which outlines specifications and applications of cupola flux. *Olin Mathieson Chemical Corp.*

Circle No. 110, Page 131-132

Human relations publication . . . for administrators of technical personnel offered as bi-monthly newsletter. Circle number below on Reader Service card, last page. *Vision Inc.*

Circle No. 111, Page 131-132

Aluminum . . . melting and holding procedures for efficient production of aluminum die castings covered in folder. *Apex Smelting Co.*

Circle No. 112, Page 131-132

Non-ferrous scrap metals . . . standard classification circular contains standards effective Aug. 1, 1958. *National Association of Waste Material Dealers, Inc.*

Circle No. 113, Page 131-132

Shell molding . . . with forsterite grains described in 4-p brochure. *Harbison-Walker Refractories Co.*

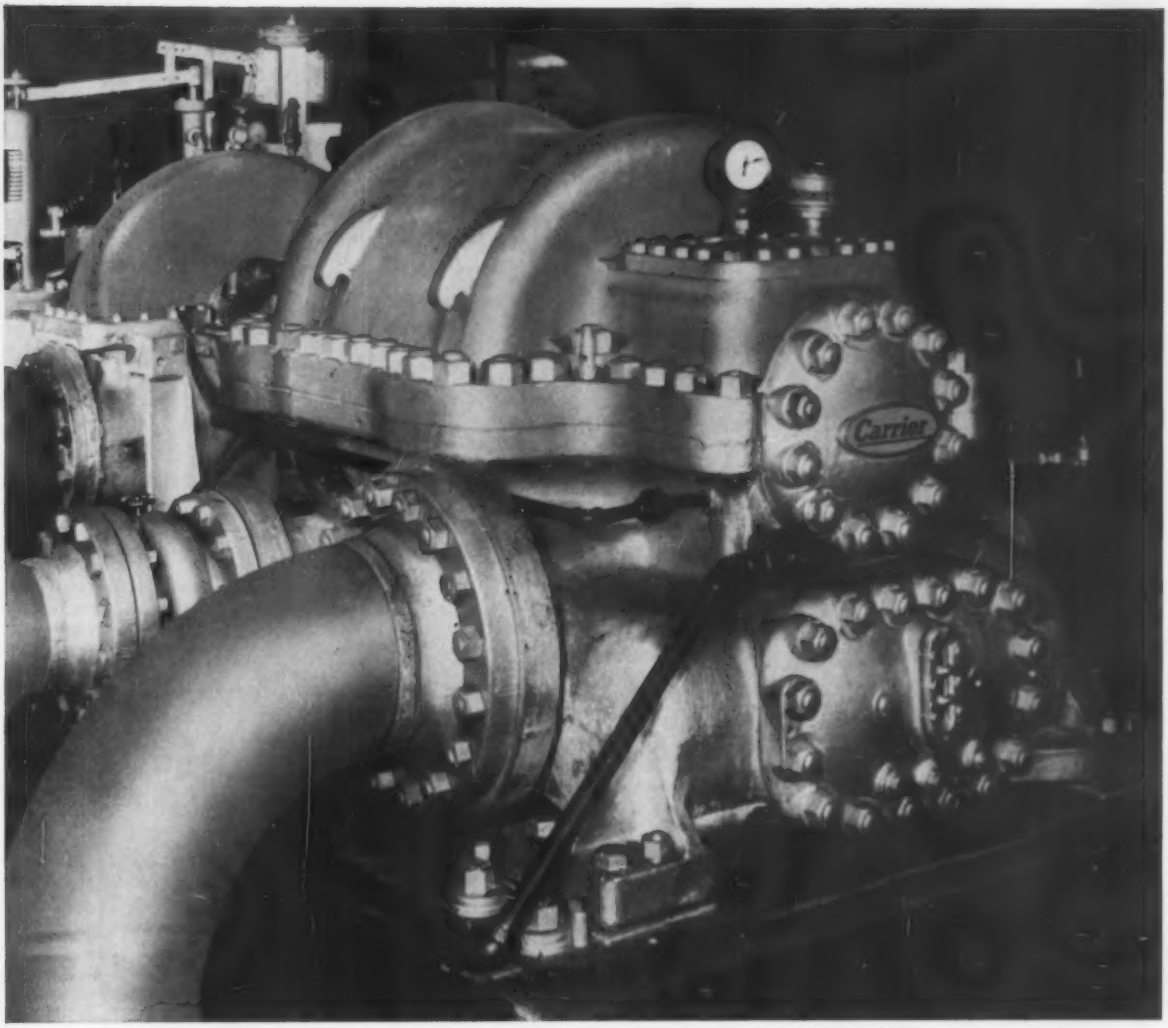
Circle No. 114, Page 131-132

Centrifugal casting . . . process fully explained and illustrated in 8-p booklet. *Centrifugal Casting Co.*

Circle No. 115, Page 131-132

CO_2 process . . . handbook illustrates equipment and describes process, 46 pp. *Carver Foundry Products Co.*

Circle No. 116, Page 131-132



4½% Nickel plus good casting makes these casings strong and tough at –185°F

Here's how the foundry solved a low temperature problem:

This Carrier #350 Compressor is designed for producing ethylene by low temperature (–185°F) high pressure (600 psi) fractionation.

Under these conditions ordinary cast steel is brittle and could easily fracture. Could the foundry turn out castings which would have high strength and toughness at the low temperatures involved?

They could . . . this way:

They made these three-ton compressor housing castings from 4½% nickel alloy steel; normalized and water quenched them, and finally tempered them. Under this treatment the castings easily exceed these minimum mechanical properties:

Ultimate tensile strength	70,000 psi
Yield strength	40,000 psi
Elongation in 2"	22%
Reduction of area	30%
Charpy keyhole impact (@ –185°F)	15 ft. lb.

Nickel does wonders for cast irons and steels destined for severe service . . . aids development of desired metal structure.

Recommend Nickel Alloys Freely

Nickel is a plentiful and versatile material and you can count on Inco Nickel's Development and Research Division for information to help you in selecting specific materials to use in particular applications.

The INTERNATIONAL NICKEL COMPANY, Inc.
67 Wall Street New York 5, N. Y.

INCO NICKEL

NICKEL ALLOYS PERFORM BETTER LONGER

UNIVERSAL
REFRACTORY GATING COMPONENTS

• The *Thinwal* construction, providing as much as *35% lighter weight* will not spall nor erode in use even at temperatures up to 3250°F. They eliminate slag inclusions, stop rejects, reduce cleaning room time.

Standards and specifications bulletin available on request. Units for special applications quoted.

UNIVERSAL
CLAY PRODUCTS CO.

1505 First St. • MAin 6-4912 • Sandusky, Ohio
P.O. Box 1631

Circle No. 161, Page 131-132

pouring off the heat

modern castings forum for designers and buyers

Many Modern Castings readers have extended their compliments on the Forum for Designers and Buyers which appeared in the March issue. Credit for this useful metalcasting compilation really belongs to the cooperative efforts of the eight trade associations that contributed this valuable material.

Many thanks to the Gray Iron Founders' Society, Malleable Founders' Society, Steel Founders' Society of America, Alloy Casting Institute, Nonferrous Founders' Society, Magnesium Association, Investment Casting Institute and American Die Casting Institute.—Editor

• I have just received my copy of the March MODERN CASTINGS and I would like to say it is the finest issue I can recall.

You and the others at AFS are to be congratulated for securing and publishing the excellent design papers from the various segments of the foundry industry. These articles are something that every design engineer should preserve in his files.

We hope that the March issue receives the recognition which it deserves.

DONALD H. WORKMAN
Gray Iron Founders' Society, Inc.
Cleveland

• Your March issue is truly excellent and I know that I echo the feelings of many when I say this.

HANS J. HEINE
Malleable Founders' Society
Cleveland

• I have just had an opportunity to look over the March issue of MODERN CASTINGS and want to congratulate you on producing an outstanding issue. It should be of great interest to design engineers.

F. KERMIT DONALDSON
Steel Founders' Society of America
Cleveland

• The March issue with its series of articles from the various foundry trade associations did an outstanding job of portraying the versatility of the casting process and the tremendous variety of mechanical and physical properties available to the design engineer in castings.

Coupled with good editorial treatment, the series places at the disposal of designers and users of castings a wealth of basic information and leads to sources of additional data that should make the issue a "must" in every casting consumer's file.

The market for castings can be enlarged through all the various efforts of individual foundries, foundry organizations and publications. Congratulations on the part you have played in the total marketing effort through your March issue.

HERBERT F. SCOBIE
Non-Ferrous Founders' Society
Evanston, Ill.

• We are glad that in your planning of the March issue of MODERN CASTINGS you were able to so broadly cover all areas. We who advocate the use of magnesium have long been in the forefront of those maintaining that material selection should be predicated upon the ultimate application and its demands. Certainly there is no better way to focus attention on this factor than in the composite presentation. MODERN CASTINGS we know has served us well and we feel that all of the other areas of foundry fabrication should feel the same way.

Thanks again for the cooperation of your publication.

JERRY SINGLETON
The Magnesium Association
New York

• This is just a note to tell you how impressed we were with the March issue of MODERN CASTINGS.

If designers and buyers of metal products are as astute as I think they are, they will put your 24 page "Forum for Designers and Buyers" into their permanent reference file. This is one of the finest collections of articles I have seen describing the various casting processes.

MODERN CASTINGS magazine is certainly to be complimented for this fine piece of work.

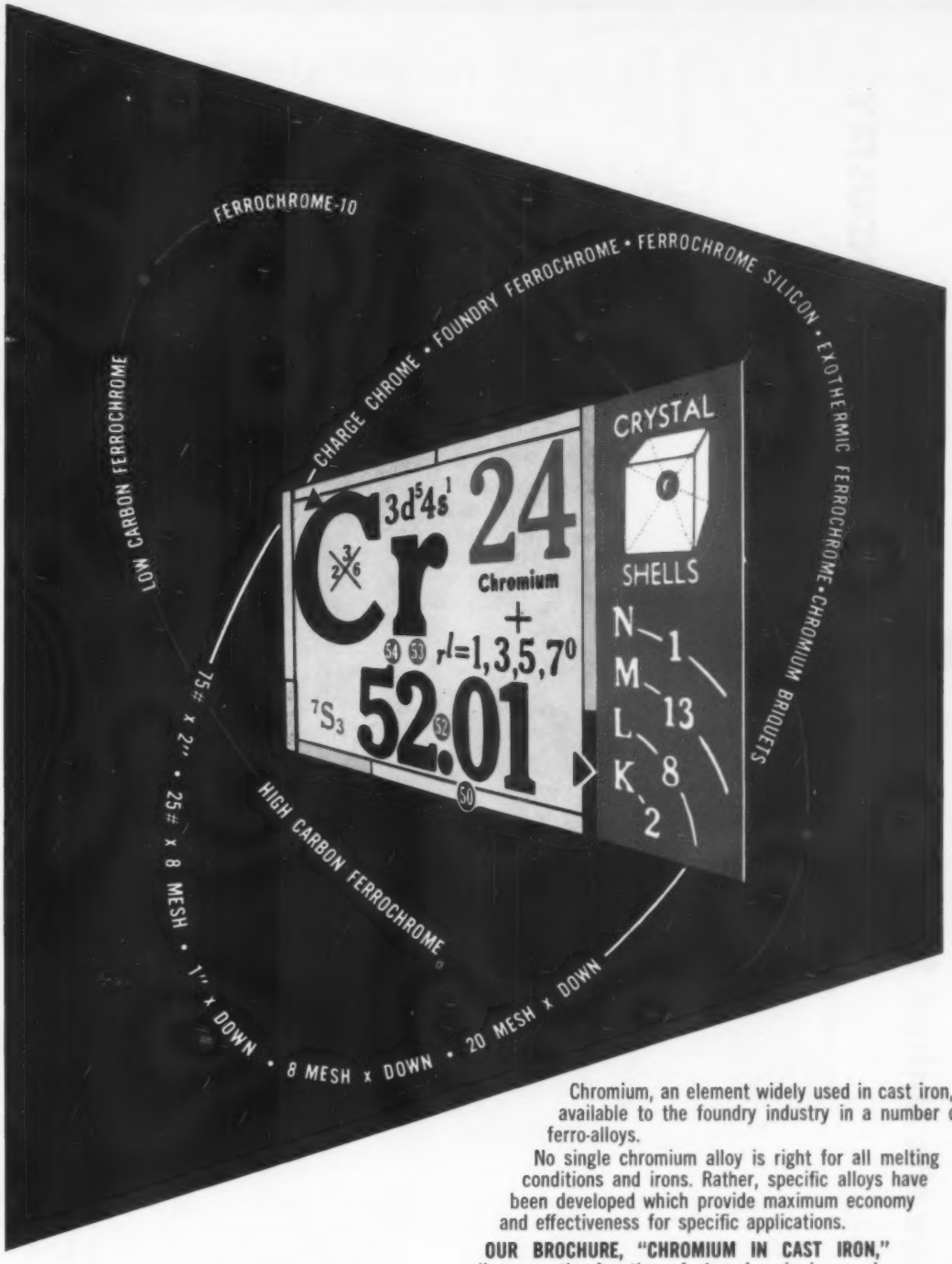
I might add that the staff of the various trade associations who participated in this forum should also be complimented for the excellent job they did in seeing to it that their industry was intelligently represented in your forum on "How and Why to Use Metal Castings."

HARRY P. DOLAN
Investment Casting Institute
Chicago

• We are very pleased with the manner in which you have handled this presentation and we sincerely hope that your readers will profit a great deal from this information.

R. E. KELLERS
American Die Casting Institute, Inc.
New York

Circle No. 162, Page 131-132



Chromium, an element widely used in cast iron, is available to the foundry industry in a number of ferro-alloys.

No single chromium alloy is right for all melting conditions and irons. Rather, specific alloys have been developed which provide maximum economy and effectiveness for specific applications.

OUR BROCHURE, "CHROMIUM IN CAST IRON," discusses the function of chromium in iron and will serve as a guide to the selection of the proper chromium alloy for your cupola or ladle needs.

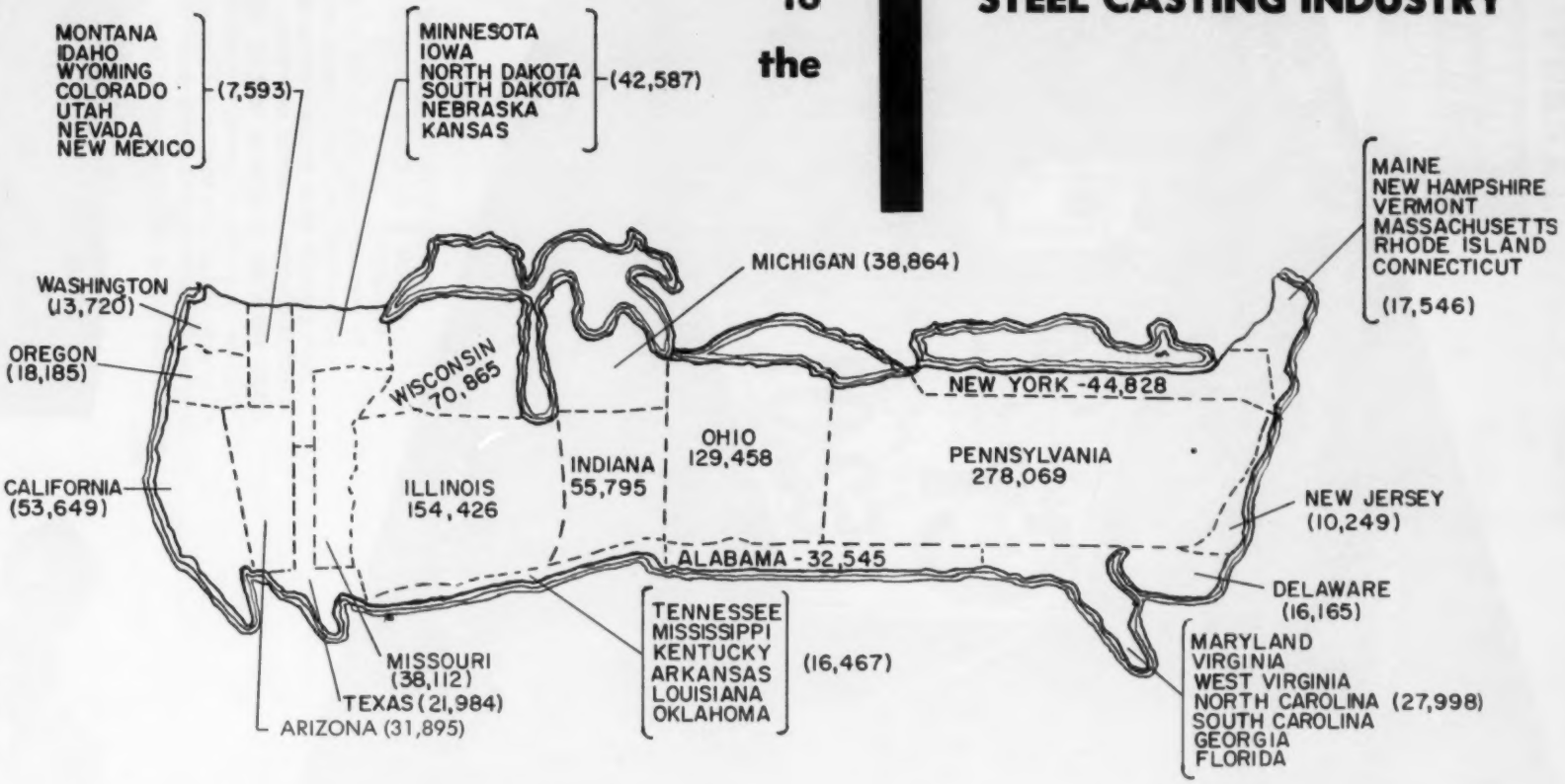
Write for your copy or contact our nearest sales office.

QUALITY · DEPENDABILITY · SERVICE

Ohio Ferro-Alloys Corporation
Canton, Ohio

BIRMINGHAM • BOSTON • CHICAGO • DENVER • DETROIT • HOUSTON • KANSAS CITY • LOS ANGELES • MINNEAPOLIS
PHILADELPHIA • PITTSBURGH • SALT LAKE CITY • SAN FRANCISCO • SEATTLE • VANCOUVER, B. C.

How the United States Looks to the STEEL CASTING INDUSTRY

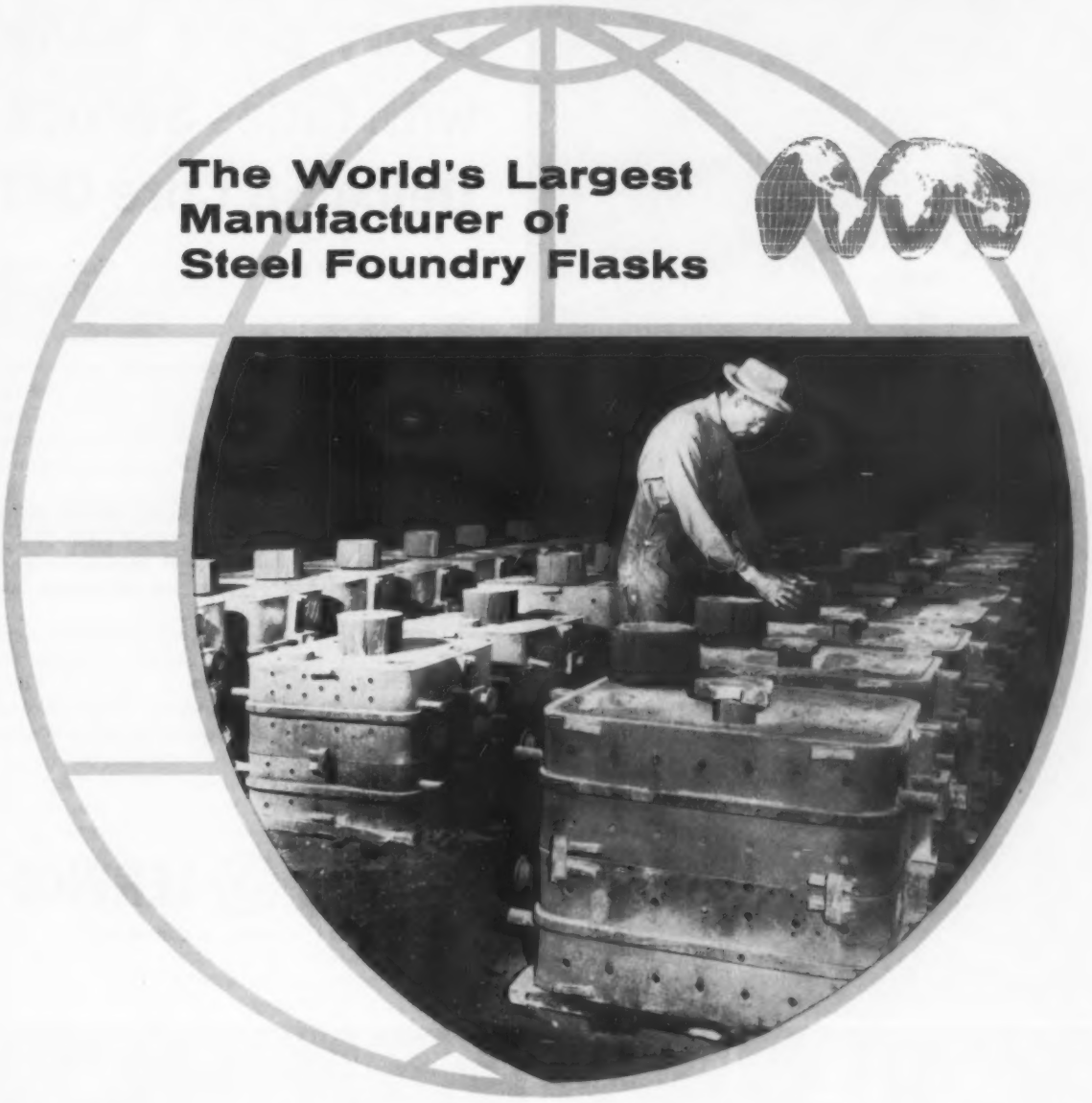


This map has been prepared by Modern Castings to show the comparative size of each State based on total shipments of steel castings in 1958.
(Units = short tons)

TOTAL U.S. SHIPMENTS OF STEEL CASTINGS FOR 1958 = 1,121,000 SHORT TONS.

You can safely rely on Sterling

The World's Largest Manufacturer of Steel Foundry Flasks



The world's largest foundries turn to Sterling, the world's largest manufacturer of steel flasks, for their flask requirements. Why? Because Sterling's specialized experience in fabricating flasks for thousands of foundries is *priceless*.

For more than a half century, Sterling Steel Flasks have been regarded as the standard of comparison by most foundrymen. Made from special hot rolled steel channel — *not pressed steel* — these flasks have many life-prolonging features. Tensile strength ranges from 60,000 to 70,000 p.s.i. with controlled copper bearing and carbon content. You get extra heavy rolled-in sand retaining flanges with square corners and full width bearing. Partings are accurately machined to .005" precision. A center-rib is welded onto each section to fortify against torsional and other strains. Frankly, can you think of any other flask with ALL these features?

* * *

Write today for your copy of the Sterling Foundry Equipment catalog.

STERLING NATIONAL INDUSTRIES, Inc.
Founded 1904 as Sterling Wheelbarrow Co.
Milwaukee 14, Wisconsin, U. S. A.
Associate: STERLING FOUNDRY SPECIALTIES LTD.
LONDON • BEDFORD • JARROW-on-TYNE, ENGLAND

AD-4831

Circle No. 163, Page 131-132

One core oil does it!

Every piece made with Cities Service Delco 58 Core Oil!

Brass Foundry Company in Peoria, Illinois, pours 1,600,000 pounds of brass and aluminum castings per year . . . keeps six core makers constantly busy . . . yet requires only *one* core oil—Cities Service Delco 58.

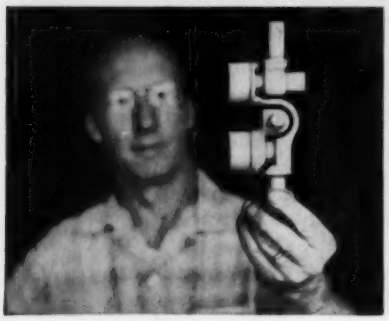
Unusual under any circumstances, this achievement is all the more significant when you realize that the cores are made for castings that must be extremely precise . . . castings made to the demanding specifications of the automotive, aviation, electrical, and agricultural industries.

Cities Service Delco 58 meets every core oil requirement because, in the words of foreman Arthur King, **"the oil is uniform from batch to batch, gives good workability, and fast-bake, has low gas content and excellent shakeout properties."**

Little can be added to Mr. King's statement except this suggestion: If you're not getting comparable results with *your* core oil, it's time to talk with a Cities Service Core Oil Specialist. Call the nearest office or write: Cities Service Oil Company, 20 North Wacker Drive, Chicago 6, Illinois.

CITIES SERVICE

QUALITY PETROLEUM PRODUCTS



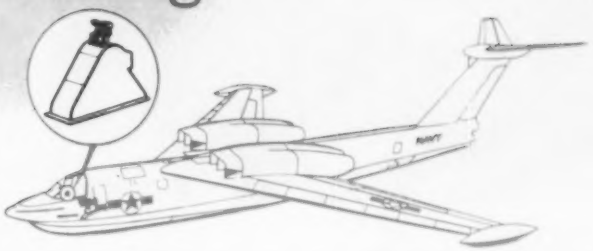
Top This For Complexity! Few cores can surpass the complex design of this one, held by core room foreman Arthur King. Like all others, it is made with Cities Service Delco 58 Core Oil.

Grandma Never Baked Like This! . . . but Grandma couldn't have taken greater pains than they do at Brass Foundry Company. One great asset is the fast-bake qualities of Cities Service Delco Core Oil.

1,600,000 Pounds Of Brass And Aluminum Castings are poured each year at Brass Foundry Co. They are made to the demanding specifications of the electrical, agricultural, aviation, and auto industries.

Circle No. 164, Page 131-132

The Design Producibility of a Magnesium Alloy Casting



PROBLEM:

How to design a rigid, light-weight support frame for flight controls and radio sets used jointly by pilot and co-pilot of a modern jet bomber.

SOLUTION:

Use DESIGN PRODUCIBILITY to provide a design which satisfies performance requirements at the lowest possible cost.

W. Krzymowski
Design Analysis

C. I. Miller
Casting Specialist

The Martin Co., Baltimore, Md.

Design producibility consists of four major steps: 1) a critical review of the design criteria, 2) an analysis of possible designs, 3) an evaluation of their costs and 4) a recommendation to the best design. Producibility is a form of value analysis with emphasis placed on cost prior to actual detail design. Without question, it is in the design phase that cost levels are set. Subsequent design tricks, clever tooling or production short-cuts cannot take the place of a correct design approach.

The first two steps are essentially a team effort, bringing together the design engineer, the producibility engineer and the cognizant process specialists. These process specialists supplement the designer's knowledge with up-to-date information on materials, processes and fabrication techniques. The designs evaluated are not merely preliminary concepts but rather feasible designs based on the latest state of the art.

There are many techniques used to arrive at an optimum design, the most successful of which is evaluation by comparison. This thought-stimulating approach eliminates generalities by considering alternate materials, methods and processes, and leads to a more conclusive recommendation in a shorter time.

A typical cost evaluation takes into consideration the following cost factors:

Engineering:—The estimate of engineering costs is prepared by the cognizant engineer. Although standardized cost data is available for many routine tasks, it will be shown later that engineering manhours can vary widely for designs that are functionally equivalent.

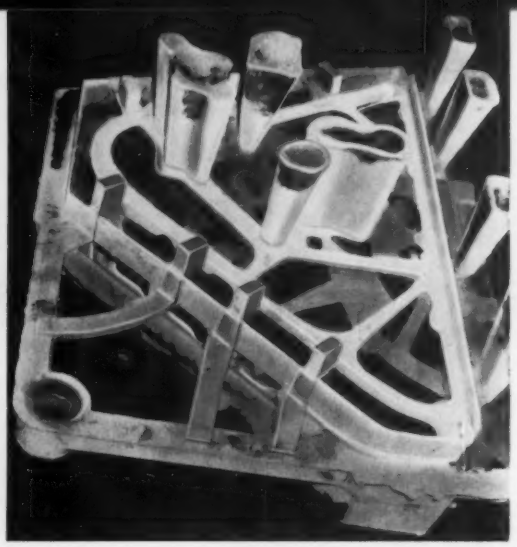
Tooling:—Tooling costs consist of process planning and tool design as well as tool manufacturing. These costs are developed from standard cost data based on type, construction and size of the tool.

Materials:—Material costs are easily obtained from suppliers or current price lists.

Manufacturing:—Before it is possible to accurately estimate manufacturing costs, a detailed operational breakdown must be made. After a breakdown is made, costs can be determined for each significant setup operation and each manufacturing step. This data is available from industrial engineering standard time values but it is put into a form more adaptable to use by the producibility engineer.

Development:—The cost of tests, both developmental and production, is an item that must not be overlooked. Some designs may require considerable testing, while others may require none. New mate-

Cope pattern shows the gating and risering for the casting used as an example by the authors.



Rough casting with gates and risers attached illustrates the relative complexity of this job.

rials or processes often sound fine until someone asks, "Who is going to pay for the tests or the development costs?" Designs should generally be planned to suit available processes and techniques. This does not mean that new materials and processes cannot be used, but that the necessity for their use should be carefully weighed against the subsequent cost of the development and testing.

Cost Summary:—After all of the above cost factors have been determined, a cost summary is prepared which takes into account the quantity to be produced and the quantity over which tooling, engineering and any other non-recurring costs are to be amortized.

Assuming that all of the designs considered are adequate and that all comparative data is available, the evaluation is still not complete. These are several additional factors, that may weigh heavily in the choice of a design.

Design simplicity:—Usually the simplest design, the one with the fewest design elements, is the most desirable, even if the estimated costs are slightly higher. Moreover, a simple design is usually more reliable.

Scheduling:—Despite our best planning, we are constantly faced with short time spans. A particular design requiring development and test may be highly desirable from every point of view except one—schedules. Limited time may make a more costly but conventional design a necessity.

Weight:—For airborne vehicles, weight is often the prime factor. A simple, inexpensive design may be scrapped in favor of a more costly but lighter item. It is not uncommon on airborne vehicles to have a specific dollar value per-pound assigned to each pound of weight saved.

This specific problem required a rigid, light-weight support frame for certain flight controls and radio sets which are used jointly by the pilot and copilot of a modern jet bomber. Since the frame is situated between the pilot and copilot, it had to be as narrow as possible. The man loads imposed on the frame structure were due to pilot effort and incident handling and servicing loads; there was no appreciable increase in loads due to mechanical advantages. The final design provided ample margins of safety for all direct loads.

An aluminum alloy built-up frame assembly and a magnesium casting were chosen for a design comparison. The built-up assembly required 4 aluminum castings, 11 sub assemblies, 46 sheet metal details, 12 machined or extruded details and 348 fasteners. The magnesium casting assembly needed only one casting, 4 sheet metal details and 62 fasteners.

Since the basic casting is self supporting, it is necessary to include in the cast design 4 simple sheet metal parts and 62 fasteners to bring the designs to a point of equivalence.

Costs of the two designs are shown on the basis of producing a standard quantity of 100 parts with tooling capable of producing 200 parts. The cost of the cast design is given as a cumulative average unit cost.

In designing the casting, one must consider not only functional requirements and appearance, but also certain factors imposed by the casting process itself. Thus, the role of the casting specialist on the team is to assist the designer in alloy selection, designing to process and making sure that this design is compatible with foundry requirements.

Process Selection

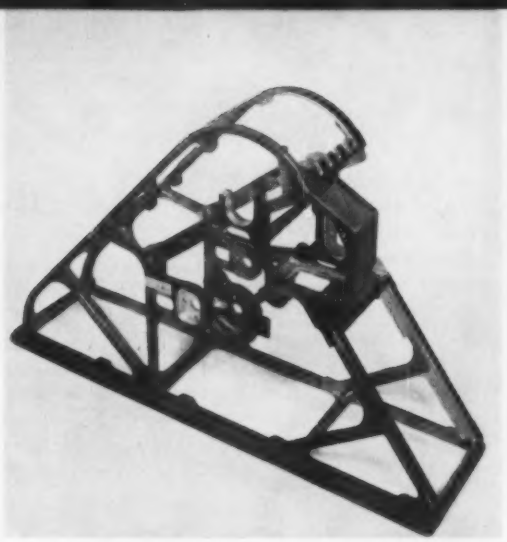
After the decision was made to use a casting, the specialist's first step was to recommend a particular casting process.

Choice of the proper casting process may depend upon the following factors:

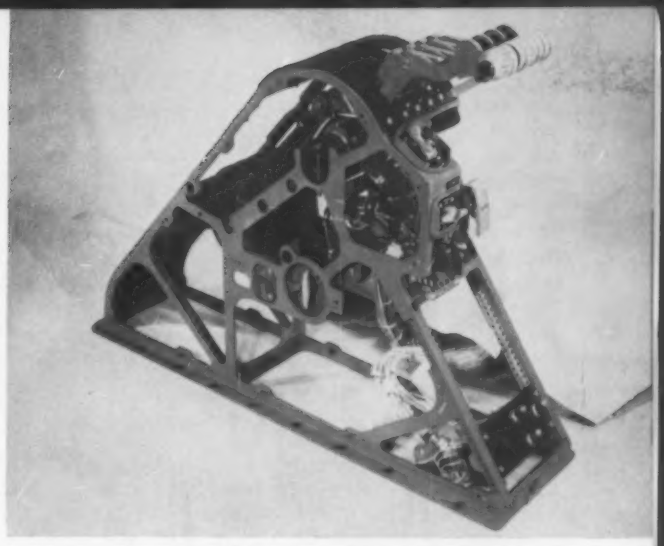
1) General size and shape
2) Wall thicknesses
3) Degree of dimensional accuracy desired
4) Loads when in service
5) Quantity required

Many castings may be made by one or more of the available processes. The advantages and disadvantages of each process must be carefully evaluated.

In studying the support frame, the selection of the sand casting process was comparatively easy, since the permanent mold and semi-permanent mold were



Fully machined casting. Light areas show the relatively small amount of machining required.



Completed assembly shows casting employed as a support frame for flight controls of jet bomber.

ruled out by size, shape, complexity and quantity.

It must be pointed out that the matter of design requirements vs. casting process is a two-way street. Not only is the process chosen on the basis of the design, but wherever possible the design is tailored to the parameters of the process. The specialist is not greatly concerned with the detail foundry practices (the type of molding, sand or core material), but he must make sure that the design is as versatile as possible and that the foundry has all possible latitude.

Detail Considerations

The configuration discussed here is somewhat more complex than the average casting. Careful consideration was given to how the gating and rising would be accomplished, how the casting would be supported during molding and heat treat and how the auxiliary tie bars and cross ribs would be placed. Some of the additional considerations are listed below.

Tolerances:—Closer-than-normal dimensions should be kept to a minimum, and every effort should be made to allow tolerances greater than one would normally think needed. In the pedestal casting, liberal tolerances were in general allowed: overall length, plus or minus 0.09 in.; overall height, plus 0.09 in. minus 0.06 in.; width, plus or minus 0.03 in. In no case was the required tolerance less than plus or minus 0.03 in. Generous allowances were made in the locations of the bases, lugs and walls which required subsequent drilling and machining. Thus, weight was saved by creating an efficient design in a lightweight material and not by skimping on dimensions.

Uniform wall and section thickness of 0.19 in. plus or minus 0.03 in.:—Section uniformity helps not only to simplify the gating and feeding problem but also to equalize the rate of solidification, an important factor in controlling the quality of this particular casting. Variations in section thickness tend to set up internal strains in the casting and cause non-uniform solidification which may result in shrinkage and cracking.

Elimination of masses:—Every effort was made to eliminate masses which would upset the solidification rate of the casting. Provisions were left for the use of chills and risers to assist in obtaining sound metal.

Design of ribs:—The ribs were designed to facilitate feeding and all-around gating.

Location of parting line:—The parting line was placed with its larger portion projecting into the drag, or bottom, of the mold. This parting line was later adjusted at the vendor's request for compatibility with his foundry facilities.

Elimination of draft:—No draft was allowed around the outside surfaces, except at the bottom which was later to be machined. The elimination of draft required the use of additional core boxes and foundry operation. On the other hand, it eliminated contour machining and the accompanying machine tools.

Machining requirements:—The internal coring was designed so that machining of internal surfaces would be possible.

Material Selection

At the same time the engineer is thinking about process selection, he must also make his decision as to material. The materials considered to make this part were aluminum and magnesium alloy. Magnesium alloy was selected on the following basis: the weight saving incurred, the capability to meet all structural requirements and the weldability of this alloy. This weldability allowed for correcting minor casting defects by welding which, in this application, could be permitted. Magnesium has good dampening properties and therefore good fatigue characteristics. Failures are seldom due to stress-mass corrosion. Another important reason for the choice is the capability of magnesium alloy to be straightened after heat treat and before aging. The aging treatment of magnesium alloy is very mild compared to the quench shock required by aluminum. The particular magnesium alloy chosen is a proven alloy and is readily available from many foundries.

It is believed that a wider use of the principles of design producibility and value analysis will result in more efficient designs and therefore in greater use of castings.

■ This paper was presented at the 14th Annual Convention of The Magnesium Association, Detroit, Mich.

and MISSILES

"A flask of angels followed by a flask of missiles." That's my favorite description of production work now taking place at Joseff-Hollywood. But, statistically speaking, I'm afraid it's a bit misleading.

Less than 13 per cent of our castings currently represent "angels," or jewelry products for which we are most widely known, while 87 per cent are components for the aircraft and missile industries.

Our reputation as a jewelry manufacturer dates back to the early 1930's, when Eugene Joseff founded our company for the specific purpose of meeting the demand for specialized costume jewelry in Hollywood's motion picture studios. And, as a matter of fact, we still make and either rent or sell about 90 per cent of the jewelry props appearing in American-made movies—not to mention a growing number of television programs.

However, we wouldn't have the largest lost-wax foundry in Southern California if our sole market were the entertainment industry.

At this writing, we have 110 employees and are monthly producing approximately 18,000 aluminum, stainless steel, silver, platinum, beryllium copper and brass castings with weights ranging from about 1/20 oz. to 12 lb.

In addition to products already mentioned, we make precision investment castings for use in both military and non-military guns, cameras and electronic equipment. Also, we manufacture a proprietary line of costume jewelry which is sold by retailers

Investing department of pioneer investment caster now producing parts for many major aircraft firms.

Vertical on-center centrifuge used for large or top quality investment castings.

Mrs. Joseff shows "angels" and missile parts now in production at her foundry.

■ About the Author

JOAN CASTLE JOSEFF, or "J. C.," as she is known to her friends, left business college to take her first job with Joseff-Hollywood shortly after the beginning of World War II. Within eight months, she became private secretary to the owner Eugene Joseff—who soon learned to admire her for her brains as well as her beauty.

As maker of most of the jewelry used in Hollywood motion pictures, Joseff was a national celebrity at that time; but, financially, he was in serious trouble due to an effort to produce costume jewelry for retail markets. Being an artist and craftsman who had never paid too much attention to the economic facts of life, Joseff couldn't quite understand what was wrong. But J. C. did.

"You're selling for about a third of the cost of production," she told him. "You've got to cut personnel, revise your price schedules, and get out of debt."

In desperation, Joseff took her advice and was delighted to find that it was good. Then he proceeded to prove that he too was capable of sound business practice—first, by making J. C. his office manager; then, his wife.

On September 18, 1948, Joseff was killed in a private plane crash.

Despite the war, during which the company had produced thousands of investment castings for the aircraft industry as well as costume jewelry, Joseff-Hollywood was not in good financial condition—due to excess-profit taxes and war-end contract cutbacks. But, by cutting costs to the bone, J. C. was able to keep the company solvent.

Simultaneously realizing that world conditions could not long forestall further government spending for weapons, she took special courses in blueprint reading and foundry techniques—thus preparing herself for the multitude of orders that became available after the Korean war began.

For her industrial success, J. C. received the 1958 Achievement Award from the National Association of Accountants.

Her favorite award, she says, came from the Executive Business Men's Club of New York which recently named her "the world's most glamorous business executive."

throughout the country.

Every now and then, I hear someone imply that a company established to produce jewelry has no business in the aircraft and missile fields. Well, the truth is that jewelry manufacturers were making investment castings of excellent quality many years before there was a need for such products in aircraft and missiles; and, consequently, we have a large accumulation of technological know-how that simply isn't available to relative newcomers.

For example, we are constantly running tests with new-type wax pattern materials; but we haven't yet found one with dimensional stability and burnout characteristics comparable to that of a wax mixture which Joseff-Hollywood was using almost 30 years ago in making such things as a belt which Rudolph Valentino wore in "Son of The Shiek" and a necklace that adorned Greta Garbo in "Camille."

Similarly, we were using a vertical on-center centrifuge to make extra-large investment castings and to improve the quality of smaller components long before many of our present competitors were familiar with the conventional off-center centrifuge.

However, I do not wish to imply that we have not found it necessary to up-date our methods from time to time. By using a new mold formula, for instance, our engineers are hopeful that we can soon investment cast titanium.

Further, we were perhaps the first to use a bell jar mounted on a three-directional mechanically vibrated table in the fabrication of investment molds which can maintain consistent as-cast tolerances of ±0.003 in. We are currently investigating the possibility of improving our moldmaking process even further by using ultrasonic agitation.

Offsetting our technical advantages to some extent has been the fact that, since 1948, the owner of Joseff-Hollywood has been a woman. There is no good reason for this because a woman with proper experience and capital can do just about anything a man can do in a managerial capacity. In fact, my late husband and predecessor Eugene Joseff considered me a better economist than he was; and, for several years prior to his death in an airplane accident, I was both formally and informally his business manager.

But let's face it: Everyone, from shop worker to customer, thinks the boss in a foundry should be a man. And, popular opinion being a formidable obstacle which nobody can really overcome, I've had to make compromises.

For example, I have had to delegate more responsibilities to my executives than would the average foundry owner in order to avoid situations in which a woman could only expect to create resentment.

Like all disadvantages, this has been a blessing in some respects. Among other things, I believe we have much better employee morale than the foundry whose owner takes pride in ruling with an iron hand; and I like to think that I have made many new friends for the company by finding more time than the average businessman does to participate in the work of civic and charitable organizations.

Anyhow, when considering the fact that we were barely making ends meet with a crew of six employees back in 1948 and that we grossed over $1,000,000 in the past "year of recession," I find it a little hard to be dissatisfied.

Joseff-Hollywood's customers at this writing include such industrial giants as AiResearch Manufacturing, Bendix Aviation, General Motors, Convair, Consolidated Electrodynamics, Darco, Douglas, Hartwell, Hughes, Marquardt, Pacific Scientific, Sargent, Hydro-Aire, Lockheed, National Presto, Northrop, North American, Monrovia Aviation, Schrillo, Seaton-Wlison, Summer's Gyroscope, Temco, Telecomputing, Vard, Whittaker Gyro and Whittaker Controls.

HOW TO VENTILATE ELECTRIC ARC FURNACES

1. ***General ventilation of the building by roof ventilators, monitor louvers or similar.***
2. ***Canopy hoods directly above furnaces, either below or above the craneways, depending on clearances and operating practices.***
3. ***Furnace-roof-mounted local exhaust hoods, either close-fitting or extending out and down past the roof ring, depending on whether or not the roof is raised during the oxygen boil.***
4. ***Direct evacuation of the furnace shell through a water-cooled elbow.***

D. M. HYSINGER
Wheelabrator Corp., Mishawaka, Ind.

Does your foundry atmosphere resemble a London fog mixed with equal parts of Los Angeles smog at the finish of an electric furnace heat? You'll be glad to know that this condition is not necessarily necessary. In this feature article, Dust & Fume Control Engineer David M. Hysinger clears the air of any misgivings you may have on how to clean-up the melting department environment.

The four basic methods of ventilating electric arc furnaces listed above will be fully explored in the following sections.

1 ROOF VENTILATORS . . . The use of roof ventilators or natural draft through monitor louvers is effective only under ideal conditions. Due to prevailing wind directions, cold air may enter the building and carry down with it some of the fume which has accumulated under the roof. The use of general ventilation to prevent the build-up of electric furnace fume is not recommended, except as a temporary measure or as a stand-by in the event of maintenance or breakdown of more effective methods.

2 CANOPY HOODS . . . One of the common types of exhaust ventilation employed is the overhead canopy hood located directly above furnace. Individual plant conditions and elevation of craneways usually dictate the location and type of canopy which can be used. The three types normally encountered are the stationary canopy over the craneways, the swivel or removable type located under the craneway, and the semi-enclosing or clam-shell type which must either swivel or be removable.

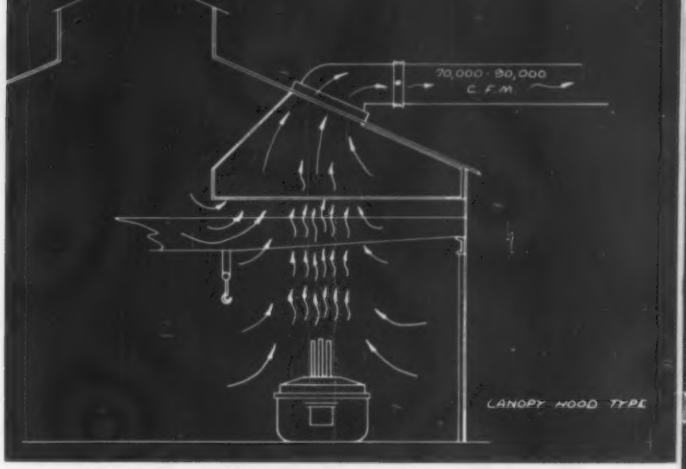
Canopy hoods located above the craneway will require two to three and one-half times the ventilation rate of the furnace-roof type hood, depending on the size of the canopy and the distance from the furnace. Regardless of the air volume used with the overhead canopy hood, the system is subject to cross drafts which deflect the rising gases beyond the reach of the hood. Entrainment of the fume in the hood is dependent upon the thermal head above the furnace to carry the gaseous fumes into the hood. Especially during oxygen lancing, the heavily fume-laden gases rise rapidly in a nearly solid column, while during other phases of the melt, the fume has a tendency to drift away before entering the effective range of the hood.

3 FURNACE-ROOF HOOD . . . The furnace-roof type hood conforms most closely to the basic principle of local exhaust ventilation, and more nearly approaches the optimum than does any other type. The standard close-fitting hood will be approximately the same diameter as the roof ring. It may be supported from the roof suspension beams or mounted on a structural framework supplied with the hood.

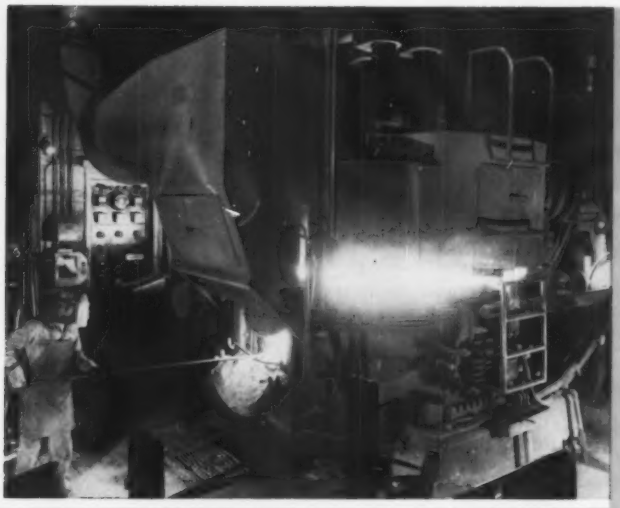
The well-designed hood is constructed of heavy steel plate and made in several sections with adequate clearances for thermal expansion. The top section normally consists of three parts constructed of heavily reinforced 1/2-in. plate. Stainless steel inserts are provided to break up any eddy currents which would cause overheating of the hood. The space between the electrodes is covered by a reinforced 1/2-in. stainless steel "Y" section which rests on suitable brackets. Hood sections extend out over the pouring spout, slagging and work doors, as required. The

take-off box, usually located above the slagging door, is equipped with balancing dampers. This take off box, or plenum, connects to the duct work of the exhaust system by means of a break flange connection.

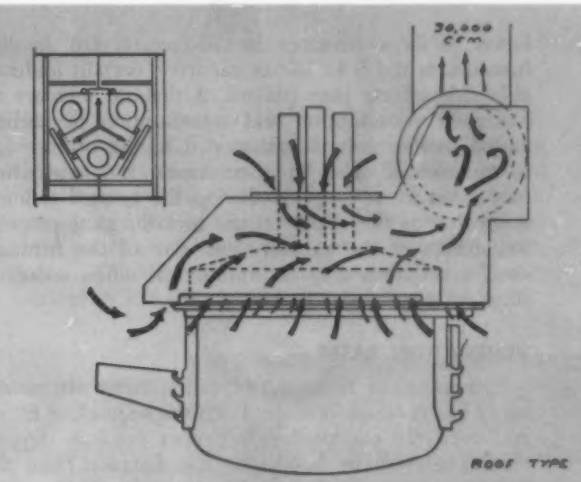
Full ventilation is applied to the furnace at all times except when tilted for pouring or slagging. With the exception of the take-off box, all sections hang or rest on pins and can be quickly and easily removed by overhead crane. In cases where the melting practice involves raising the roof during oxygen lancing, the hood is made 8 in. to 12 in. greater in diameter than the roof ring. The gases and fume escaping from around the periphery of the roof ring are quickly drawn into the "skirt" of the hood. This type of hooding requires 10 per cent to 15 per cent greater air volume than the close-fitting type hood.



Canopy hood ventilators are installed directly over the furnace. Three basic types are built. Cross drafts reduce effectiveness of this system.



Furnace-roof hood is best available ventilation system. Close-fitting hood has been raised for oxygen lancing but skirt on hood controls fumes.

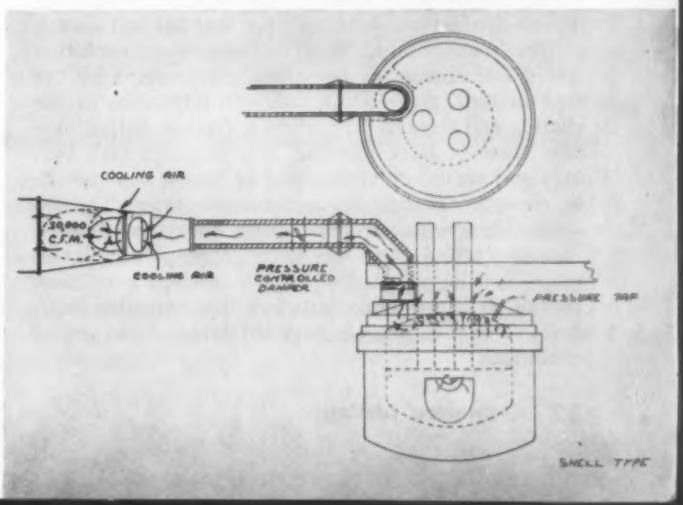


Full ventilation of the furnace is provided by furnace-roof system except when the furnace is tilted. Schematic shows components of system.

Furnace-shell evacuation is satisfactory for furnaces with roof ring diameters larger than 15 ft. Not used if reducing slags are employed.

4 FURNACE SHELL EVACUATION . . . Particularly in the case of furnaces having roof ring diameters in excess of 15 ft, fume control can be accomplished by evacuating the furnace shell through a water-cooled connection. Fume control by this method is more complex than the external exhaust ventilation because of its effect on metallurgy and the necessity of cooling the extremely hot gases. Cooling must be accomplished either by water sprays, tempering air or radiation coolers before passing to the filtering equipment.

It is reported that the direct shell tap for the venti-



Interior of room containing cloth tubular-type dust collector bags for furnace ventilation systems.

lation of large furnaces is satisfactory. On smaller furnaces in the 5 to 15-ton capacity, certain undesirable side effects may prevail. A definite increase in electrode consumption and consumption of carbon added to the melt is indicated. Chilling of the slag is experienced and, in some cases, the ventilation may need to be stopped during the critical refining stage due to the effect on the metallurgical process. Regardless of the capacity and size of the furnace, shell evacuation may be impractical when reducing slags are employed.

VENTILATION RATES

Estimation of furnace ventilation rates are necessarily based on experience. With the semi-close fitting and overhead canopy hoods, proper volumes depend on the size of the hood and the distance from the source of fume emission. In the case of the roof-mounted hood, there is a definite relationship between the size of the hood and the size and type of furnace. Normal ventilation rates must be sufficient to provide good fume control and prevent overheating of the hood. Since most furnace fume control installations utilize the cloth-type collector for gas cleaning and ambient air for gas cooling, the ventilation rate must be sufficient to maintain temperatures of 275F and below.

The biggest influencing factor on fume control requirements is the intensity of the thermal and chemical reactions in the furnace. The rate of gas evolution and gas temperatures are directly influenced by the type of melt, the melting rate, the impurities in the charge, and the rate of carbon reduction during oxygen lancing. Back-charging oily turnings and borings and scrap containing zinc or magnesium results in explosive flashes of incandescent gases. The resultant temperatures will depend on the ventilation volume carried into the hood. Normal ventilation rates must be adjusted when any of these conditions prevail. It is not unlikely to find that twice the "normal" ventilation rate is required under such special conditions.

The most widely known and acceptable method of collection of electric furnace dust and fume to date has been with the mechanically shaken tubular-type cloth filter.

DUST COLLECTION

Provided proper ventilation volumes are maintained, the gas temperatures do not normally exceed 250F at the collector. Because of occasional uncontrollable or unpredictable temperature surges above 275F (the maximum operating temperature for Orlon filter bags), it is common practice to provide an automatic air-operated tempering air damper which opens when necessary to protect the filter cloth.

The use of one baghouse for each furnace ventilated requires more tempering air to compensate for temperature surges which occur during different phases of the heat. By ventilating two or more furnaces through a single collector, temperature surges from one furnace tend to be levelled off by the gases from the second or subsequent furnaces. Of course, one must be careful to avoid oxygen lancing or carbon reduction at the same time in all furnaces.

The tubular cloth collector will meet any existing or proposed air pollution code. Collection efficiencies in excess of 99 per cent can be regularly obtained. Many operators install tubular cloth collectors—insure against further expenditure should there be enactment of more rigid air pollution regulations.

Although an abundance of knowledge has been accumulated over the past ten years in the field of cloth filtration as applied to the collection of hot gas contaminants, continuing research and development is directed at the electric furnace fume problem. The program at Wheelabrator is carried out not only on a laboratory basis but also on its own production facilities, which involve five electric arc furnaces used in the production of steel abrasives. Fume control is obtained by three continuous automatic-type collectors using Orlon cloth. Four furnaces are equipped with roof-mounted hoods and the fifth employs the direct shell tap method.

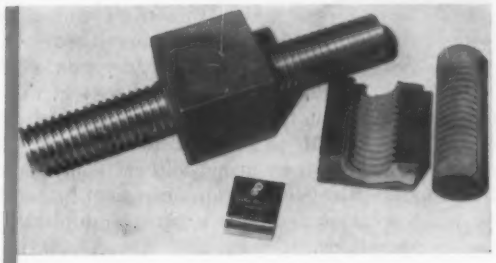
Report on the

ENGINEERED CASTINGS SHOW

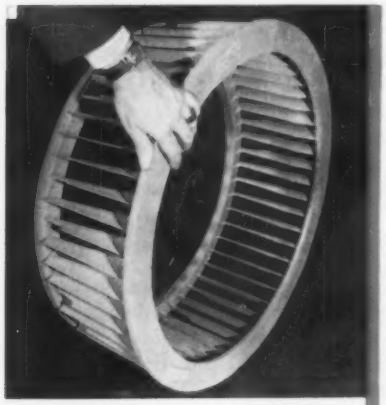
PROVING GROUND FOR METAL CASTINGS PROGRESS

The 2d AFS Engineered Castings Show held in Chicago, April 13-17, was indeed a veritable proving ground for metalcastings progress. The many foundry-exhibitors proved that they had technical know-how and proved they knew how to use it to produce engineered castings. Since seeing is believing, these exhibitors backed up performance claims with the real thing – the castings.

Here are just a few of the many outstanding examples of castings which were exhibited at the Show.

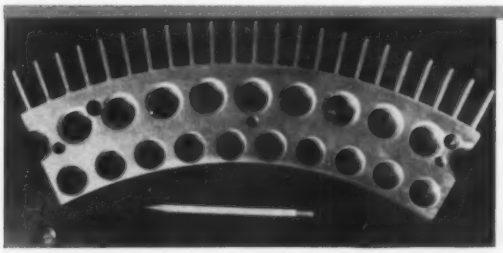


Here's How Paxton-Mitchell Co., Omaha, Neb., makes an SAE-63 bronze lift nut for raising and lowering water control slide gates. Threads on the nut are cast-to-size – thanks to the shell core shown on right. View of sectioned nut, in center, shows how machining of threads was completely eliminated. On left an Acme thread machined stem is shown in lift nut simulating service conditions.



Here's How Bendix Foundries, Teterboro, N.J., cast 80 extruded magnesium blades integrally into two magnesium rings to form an airflow unit for a jet engine. By replacing a former tedious welding fabrication technique, company saved 40 per cent and netted a superior structure.

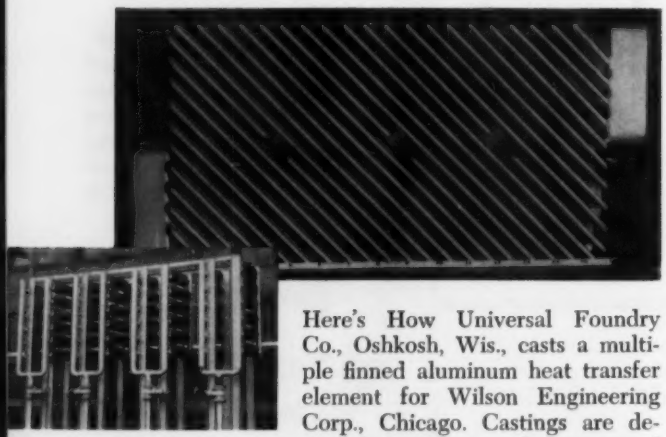
Here's How Fabricast Div., GMC, Bedford, Ind., uses a number of aluminum castings to build the cross drive for an 850-hp tank transmission. The upper and lower housings weigh 250 lb apiece and are cast in alloy 355 in green sand molds using dry sand cores. The converter elements shown inside the housings are cast in a semi-permanent mold. Drag is a shell mold with plaster cores forming the veins and cope is a permanent mold.



Here's How B-Mold Div., Buckeye Brass & Mfg. Co., Mansfield, Ohio, uses precision permanent molding to cast armature finger plates which bolt on sides of locomotive electric generator rotors. Cast in segments of 1/6 of a circle, these aluminum bronze plates weigh 7.5 lb and have a tensile strength of 95,000 psi. With each segment having 26 fingers, a lot of machining was eliminated by going to permold casting.

1959 CASTINGS CONGRESS PAPERS

Here's How the Engineered Castings Div., American Brake Shoe Co., Medina, N.Y., casts-to-size automotive forming dies in flame-hardening alloy gray iron. R. E. Ruf shows a steel door pillar stamped on this 700-lb female die pictured below. A savings of 10 to 25 per cent on overall die construction is effected by accurately casting the dies 30 to 50 thousandths oversize. Dies can then be finished by hand without need for expensive duplicating machinery operations.



Here's How Universal Foundry Co., Oshkosh, Wis., casts a multiple finned aluminum heat transfer element for Wilson Engineering Corp., Chicago. Castings are designed to either cool compressed air or heat fuel oil on board locomotives. Castings must be pressure tight to hold oil at 300 psi, compressed air and steam. Lower pic shows a bank of these castings installed by Wilson to cool compressed air and steam for Chicago & Eastern Illinois R.R. compressors.

Here's How Morris Bean & Co., Yellow Springs, Ohio, uses the Antioch process to cast a hollow aluminum mandrel for shaping the solid fuel propellant charged into a rocket motor. Vice President R. H. Hollister explained that casting has to be radiographically sound and surface-perfect to avoid entrapment of dangerous explosives. Casting is 8 ft tall, 16 in. diameter and has 1/2-in. wall.

Continued on page 113

■ The technical articles appearing in this preview section of MODERN CASTINGS are the official 1959 AFS Castings Congress papers—the most authoritative technical information available to the metalcasting industry.

Nearly 100 technical papers presented at the 63d Castings Congress of the American Foundrymen's Society will be printed here prior to publication of the complete 1959 AFS TRANSACTIONS.

■ Written discussion of these papers is welcomed and will be included in the 1959 TRANSACTIONS if submitted by September 1. Discussions should be addressed to the Technical Department, American Foundrymen's Society, Golf and Wolf Roads, Des Plaines, Ill.

■ The complete case-bound volume of 1959 AFS TRANSACTIONS, including all papers and all discussion, will be published December 1. Orders for this volume should be addressed to the Technical Department.

PRESSURE TIGHTNESS OF 85-5-5-5 BRONZE

relationship of thermal gradients during solidification

PROGRESS REPORT OF AFS BRASS and BRONZE DIVISION RESEARCH COMMITTEE

By Richard A. Flinn and Chester R. Mielke

ABSTRACT

Previous work established the marked influence of different types of chilling as well as risering upon the pressure tightness of 85-5-5-5. The purpose of this investigation was to measure the thermal gradients during solidification to provide a quantitative evaluation of different risering and chilling combinations.

The data indicate that pressure tight castings were obtained in 2 in. square bar sections when the thermal gradient exceeded 60 F/in. By the use of tapered chills it was possible to attain this gradient in bars up to 9 in. in length.

An end chill produces gradients over 60 F/in. for 4 in. along the bar, while the uninsulated risers develop gradients of this magnitude for less than 1 in. The combined effect of riser and tapered sidewall chills results in a gradient of 60 F/in. or more for 3 in. from the riser.

Preliminary experiments involving the effects of riser size and bar thickness are discussed.

INTRODUCTION

The purpose of this project, which has been supervised by the Brass and Bronze Division of the AFS,* has been to determine the principal variables responsible for control of pressure tightness in 85-5-5-5 bronze. This alloy was selected because it is the most widely used copper base alloy. However, the procedures have deliberately been developed so that any other copper base alloys can be readily evaluated in similar fashion.

Previous reports[1,2] indicate that pouring temperature and chill geometry are important in controlling pressure tightness.

The objectives of the present work were to determine quantitatively the thermal gradients produced by the riser and the chills as the following features of mold design were changed:

1) Casting length.
2) Riser size.
3) Casting thickness.

In this way the relative effectiveness of risers of different geometry and chills of different design can be evaluated for practical application to casting problems.

PROCEDURE

The details of procedure have been described in previous reports.[1,2] Briefly, a constant metal history was maintained by using charges composed entirely of ingot from two interrelated heats, donated by the Brass and Bronze Ingot Institute. Melting was conducted in a gas-fired crucible furnace under oxidizing conditions. Zinc and phosphorus copper additions were made as described previously. Temperatures were measured at tap and pouring with an immersion chromel-alumel thermocouple and calibrated high-speed recorder.

In addition to the standard 12 x 2 x 2 in. bar with 4 in. diameter riser, variations in riser size and in bar thickness were planned as indicated on the appropriate data sheets.

Pressure tightness was evaluated, as discussed previously, in a 2 x 12 x $\frac{1}{32}$-in. specimen cut horizontally through the center of the test casting. Of course, in the special 6 in. and 9 in. long bars this test section was only as long as the bar. When thermocouples were employed at the center line, the section for pressure testing was displaced less than $\frac{1}{4}$-in. to avoid the thin silica protection tubes. Previous work indicated that in a 2 x 2 in. square section this displacement will not affect the pressure test results appreciably.

To determine thermal gradients thermocouples were inserted in the mold, as illustrated in Fig. 1. Thermocouple locations are indicated on the graphs showing thermal gradients.

Thermocouple Technique

Since considerable development work was necessary to obtain really sensitive thermocouples, a brief description of the final technique may be of interest. To minimize thermal lag, 28 gage (0.0126 in.) chromel and alumel wires were butt welded using a condenser discharge arc. The thermocouple was then slipped into a fused silica protection tube which had been drawn from 0.075 in. O.D. and 0.039 in. I.D.

*Membership of the Brass and Bronze Research Committee: F. L. Riddell, *Chairman;* E. F. Tibbetts; R. A. Colton; G. LeBrasse; R. W. Ruddle; C. W. Ward; H. Bishop; S. C. Massari, *AFS Technical Director;* R. B. Fischer; and R. J. Keeley.

R. A. FLINN is Prof. and C. R. MIELKE is special student, Dept. of Chemical and Met. Engrg., University of Michigan, Ann Arbor.

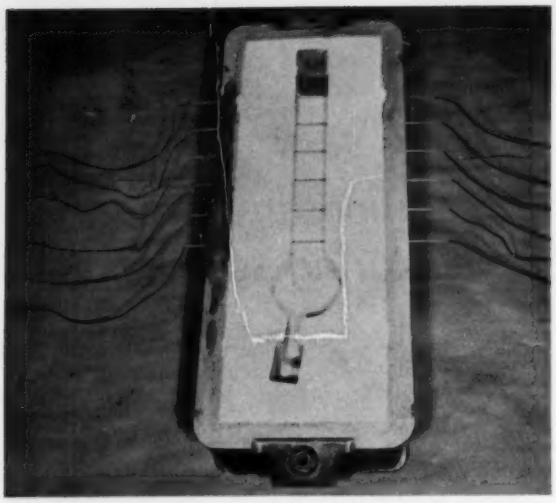


Fig. 1 — Drag half of mold showing location of thermocouples.

to an O.D. of approximately 0.045 in. and 0.020 in. I.D.

With this technique thermocouple assemblies of small thermal capacity and good sensitivity were obtained. These thermocouples reached the metal temperature by the time the mold was filled (12 sec).

To permit the insertion of these delicate tubes in the mold, pattern and flask alterations were made, as illustrated in Fig. 2. Therefore, oversize holes were present in the mold and flask. After locating the thermocouples with the butt weld at the centerline of the bar, the tube position was fixed with a small amount of core paste. An assembly ready to pour is illustrated in Fig. 3. Examination of the castings showed no shifting of the thermocouples.

The thermocouples were connected to a rotating silver commutator leading to a high-speed recorder. In this way each couple gave a reading every 6 sec. A typical recorder trace is shown in Fig. 4.

THERMAL GRADIENTS CALCULATIONS

From the cooling curve data of Fig. 5 it is possible to compute thermal gradients in several ways. The tangent method (Method 1) is to determine the temperature at different stations at the different intervals after pouring, as illustrated in Fig. 6. Then, from these curves the thermal gradient at any desired station and temperature can be determined by drawing a tangent and taking the slope. A sample calculation is shown on the graph. While this meets the proper definition of a gradient dT:dx, it has several disadvantages.

First, if the gradient is taken at the solidus the colder, solid material influences the numerical value of the gradient through its effect upon the curve. However only the hotter, still liquid material is of importance in feeding. Second, the tangent must be drawn to a curve derived from a second interpolation of the measured data, and is therefore not as accurate as if the raw data could be used.

To meet these objections an alternate and much simpler method may be used (Method 2). If the gradient at a given station is desired at the solidus, for example, the temperature difference to the nearest (hotter) station is determined from the original cooling curves and divided by the distance. This calculation really gives a secant rather than a true tangent, but has the advantage of simple direct computation. It also measures only the upstream gradient to the source of liquid metal. It is true that if the distance to the upstream thermocouple varies from 1 in. to 2 in., the variation between the secant and the tangent methods will vary.

Computations by both methods are illustrated in Figs. 5 and 6.

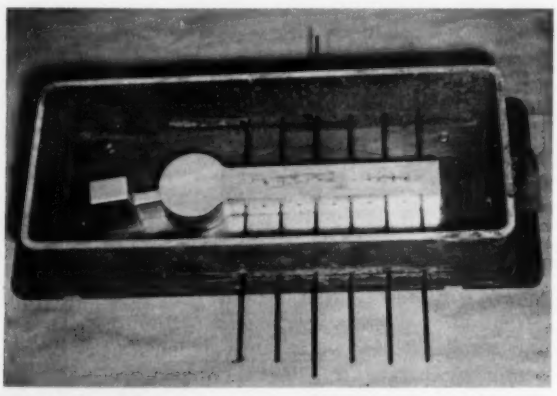


Fig. 2 — Pattern and flask modifications for thermocouple insertion.

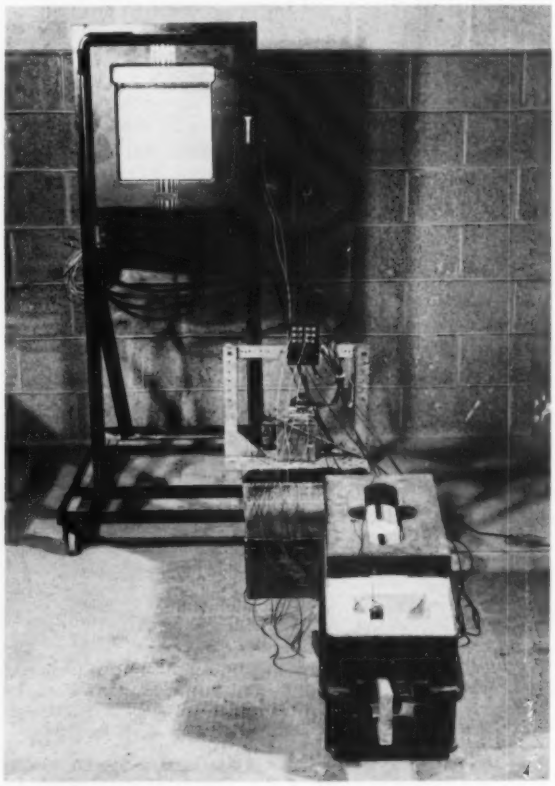


Fig. 3 — Mold assembly and recording equipment.

EFFECT OF TEMPERATURE SELECTED FOR THERMAL GRADIENT MEASUREMENT

The liquidus temperature will vary in the range 1824 F - 1852 F depending upon cooling rate as indicated in the graphs. Because of the long freezing range and high conductivity the solidus is not indicated by the graphs. A constant reference solidus of 1568 F[3] was used. The choice of absolute temperature for the solidus is not critical because of the slow change in cooling rate in this temperature range.

In addition to calculating the thermal gradient at the solidus, determinations at other temperatures between liquidus and solidus were also made. In addition to the general interest of these data, these calcu-

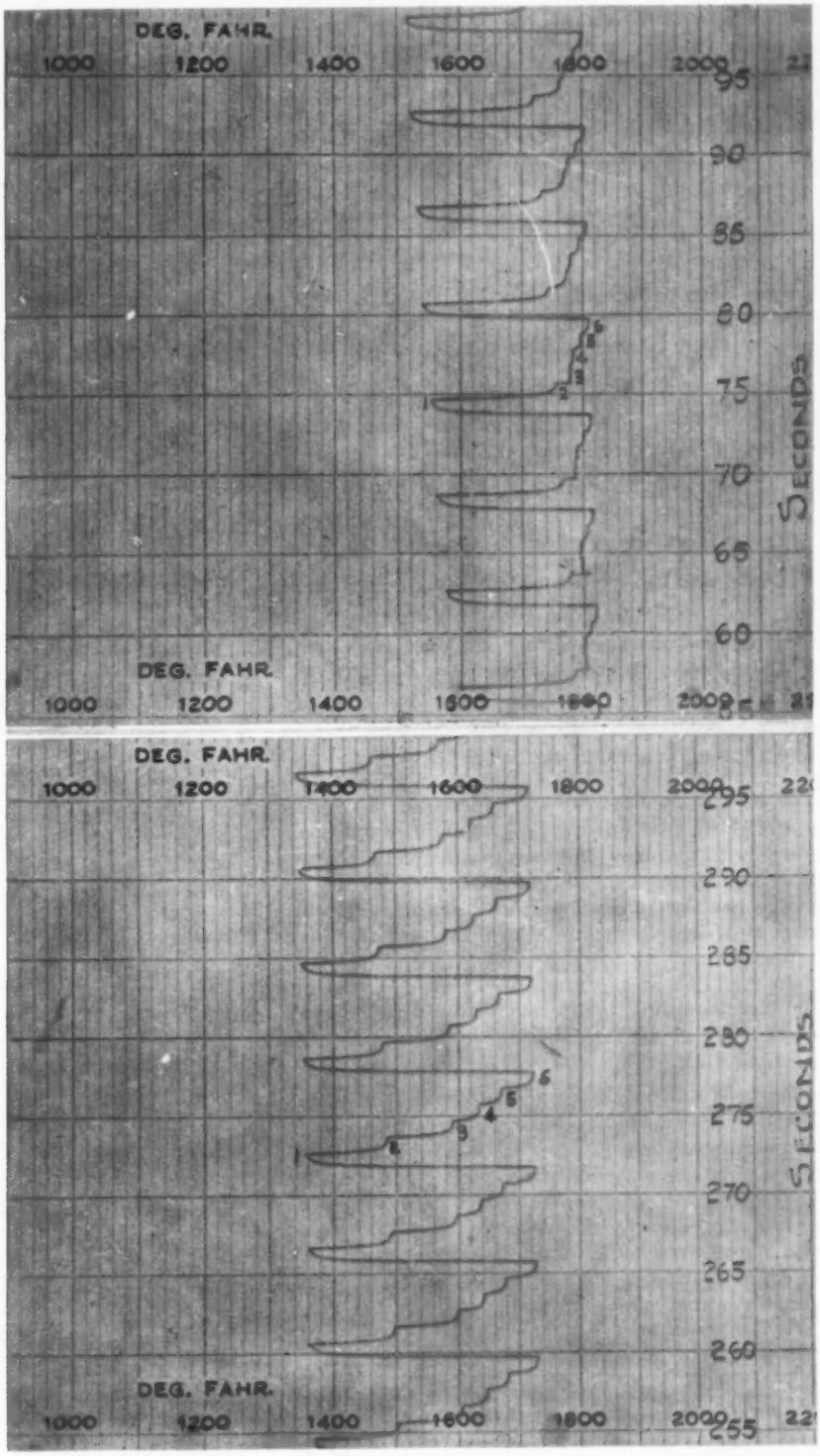


Fig. 4 — Typical recorder trace showing a small gradient 50 sec after pouring (top), and a larger gradient at 250 sec after pouring (bottom).

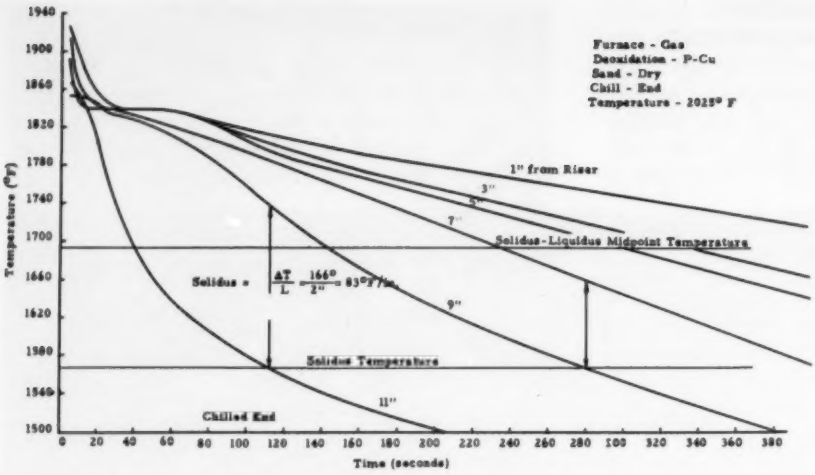


Fig. 5 — Typical cooling curves, secant method, 2 in. bar.

lations were performed because of the complex nature of the 85-5-5-5 bronze system. The last portions to solidify are richer in lead and may not require extensive feeding.

Also, a satisfactory gradient may be necessary in the middle of the freezing range to reduce the distance of liquid metal transport through the dendritic growth. In general a higher gradient is developed at the solidus.

DISCUSSION OF RESULTS

The results may be considered in three sections:

1) 6, 9 and 12 in. bars with wedge chills.
2) 12 in. bars with varying riser size.
3) 12 in. bars of different thickness.

In each case the effect of mold design upon pressure tightness will be discussed first, followed by consideration of the thermal gradients.

6, 9 and 12 in. Bars with Wedge Chills (poured at 2025 F)

Pressure Tightness. Previous work had indicated that the 12 x 2 x 2 in. bar was not sound even when wedge chills were employed. Therefore, shorter bars were produced to determine the limiting conditions for soundness.

In Fig. 7 the data show that 6 and 9 in. bars may be made pressure tight using the wedge chill technique. The 12 in. bar exhibited leakage, as noted in previous work.

Thermal Gradients. The thermal gradient data, Figs. 8 and 9, provide helpful quantitative information in explaining the leakage rates. In the sound 6 and 9 in. bars the minimum gradient was 60 F/in. In the 12 in. bar where the gradient was over 60 F/in. solidus sound material was also encountered, while leakage was noted where a lesser gradient was present. The effect of shortening the bar was to increase the minimum gradient as follows:

Bar size, in.	Approx. minimum gradient at solidus, F/in.
12	36
9	60
6	150

The effects of the riser and the end chill are also of interest. In the 12 in. bars, the gradient at 3 in. from the riser is 60 F/in., while 3 in. from the end chill the gradient is also about 60 F/in. The gradient produced by the end chill is less than if the walls were of sand. This effect is due to the fact that the sidewalls are almost completely graphite, and therefore the gradient obtained is due mostly to end effects, that is, the presence of the end surface.

In the case where only an end chill is present (sand

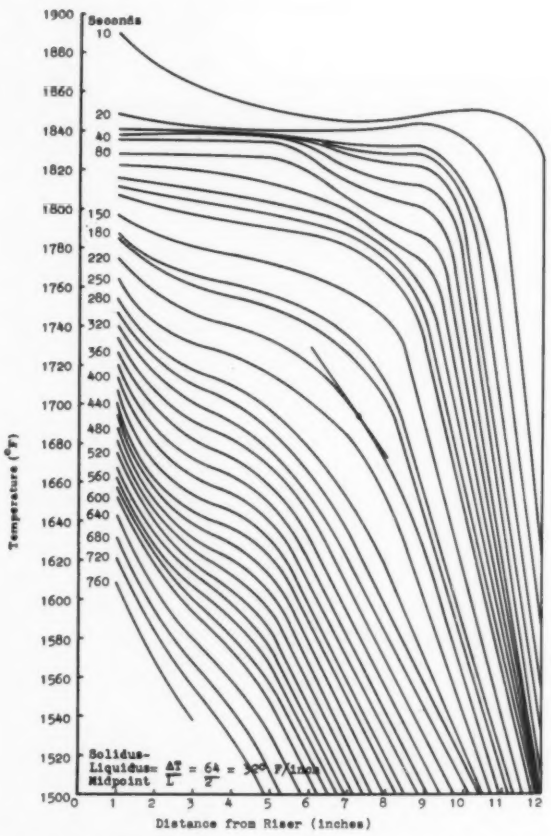


Fig. 6 — Typical iso-time cooling curves, tangent method, 2 in. bar.

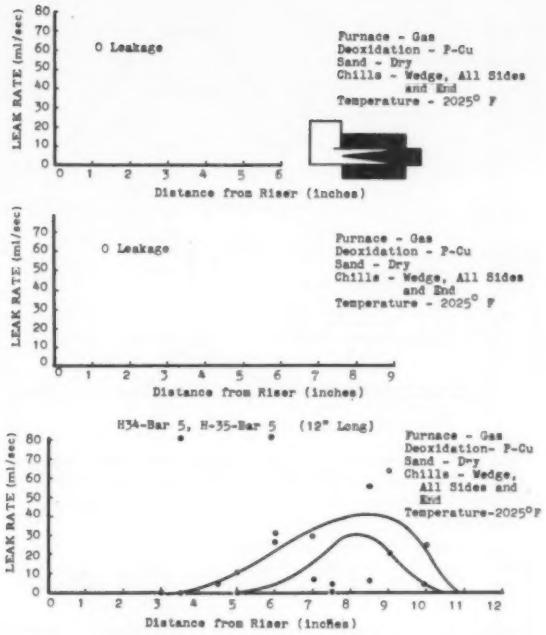


Fig. 7 — Effect of length of bar upon leak rate (wedge chills), for different bar lengths. Top — 6 in. long, center — 9 in. long, bottom — 12 in. long.

sidewalls) the gradient is due to the combined effects of the end surface and the difference in sidewall material. However, by the use of tapered graphite chills it is possible to ration the end wall effect to produce a satisfactory gradient further into the mold. This point is confirmed by the data of the next section.

Variations in Pouring Temperature Effect

Preliminary data indicating the effects of variations

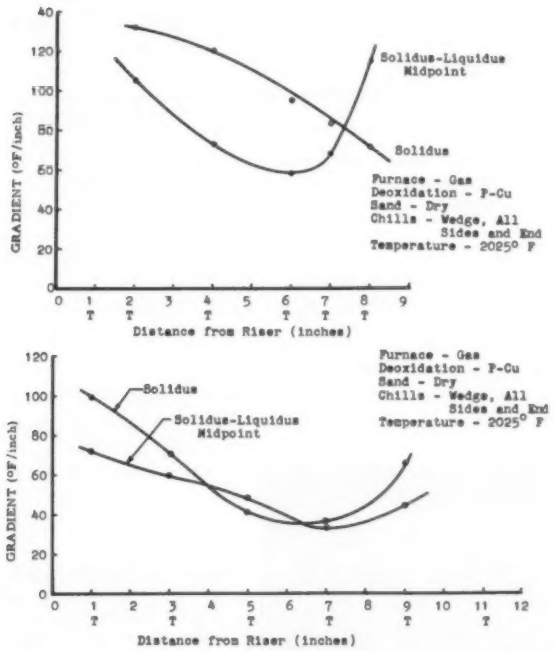


Fig. 9 — Thermal gradients in 9 in. (top) and 12 in. (bottom) bars.

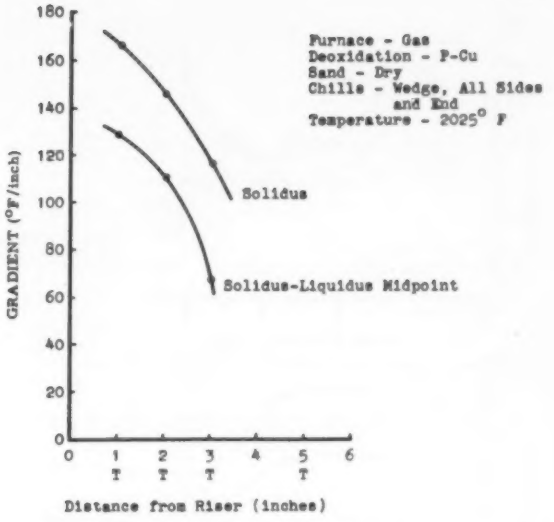


Fig. 8 — Thermal gradients in 6 in. bar.

in pouring temperature are given in Figs. 10, 11, 12 and 13.

Two bars, 9 in. and 12 in. long, respectively, were poured at different and higher temperatures (Figs. 10 and 11). The 12 in. bar poured at 2275 F exhibited severe leakage, probably due to the greater gas content of the metal in the bar. The greater reaction rate, and longer reaction time between metal and mold, probably leads to the higher gas content. These data indicate that the effects of a good mold design may be nullified if excessive pouring temperatures are employed.

It is interesting that somewhat greater thermal gradients were obtained at the higher pouring temperatures. The greater solution, and later evolution of gas, was apparently more important than the thermal gradient in the 12 in. bar. A photograph of the midsection of this bar is shown in Fig. 12. The 9 in. bar poured only 150 F above the standard temperature of 2025 F was still sound.

Additional experiments were performed to determine the effect of reducing pouring temperature below the standard of 2025 F. Previous work[1,2] indi-

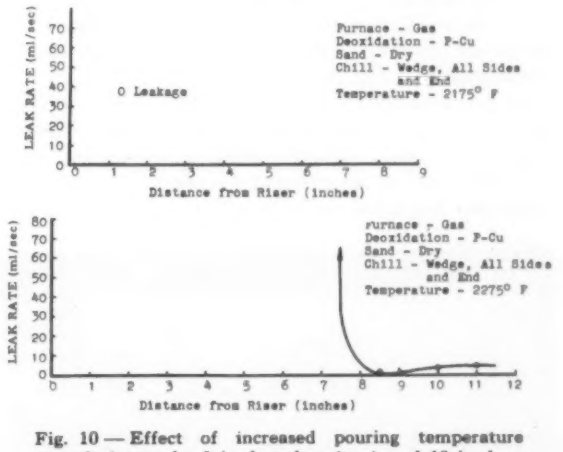


Fig. 10 — Effect of increased pouring temperature upon leak rate for 9 in. long bar (top) and 12 in. long bar (bottom).

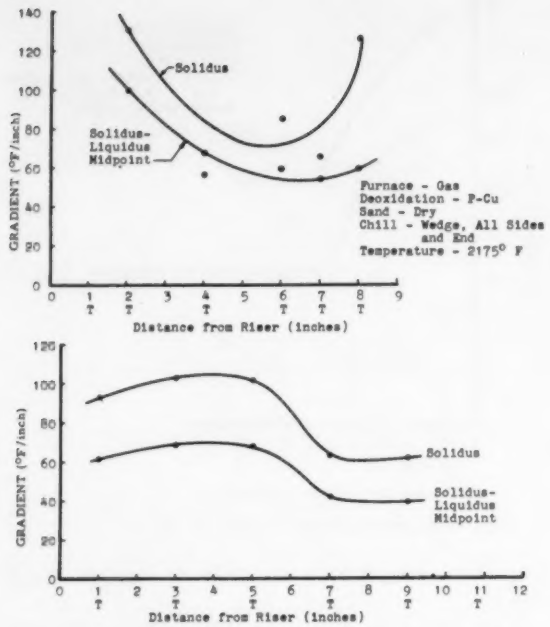


Fig. 11 — Thermal gradients of 12 in. (bottom) and 9 in. (top) bars poured at higher than standard temperature.

cated that this was helpful for bars cast with sand sidewalls and end chills. A small reduction in leakage was encountered, as shown in Fig. 13.

12 in. Bars With Varying Riser Size

The results of preliminary experiments in this field are given in Figs. 14 and 15.

A variation from −44 per cent to +37 per cent in riser size, referred to the standard riser, had the following effects. The larger riser provided a sounder section at the risered end of the bar than the smaller riser, but no improvement over the standard riser. The leakage is similar in all three cases at stations further than 3 in. from the riser.

The thermal gradient data provide an interesting quantitative verification of these effects. The (solidus) gradient at 7 in. from the riser, for example, is 44 F/in. in bars with small and large risers. This certainly indicates the influence of the riser is limited as would be expected. Further work is contemplated employing insulated risers.

It is important to notice that this experiment, which was quite independent of the first (dealing with bar length), provides striking confirmation of the interrelation of thermal gradient and pressure tightness. Examination of the leak rate data for all

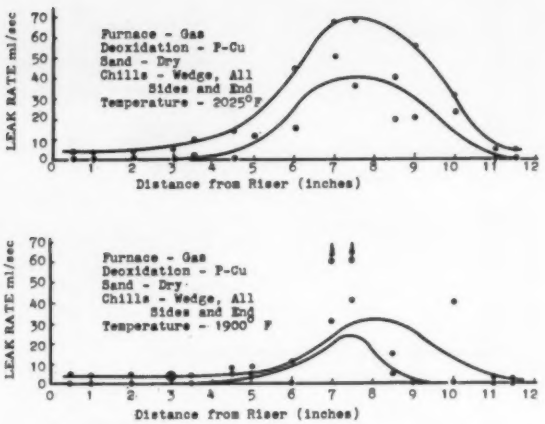


Fig. 13 — Reduced pouring temperature effect upon leak rate. Top — H31, bar 1 (black dot) and bar 2 (circle). Bottom — H31, bar 3 (black dot) and bar 4 (circle).

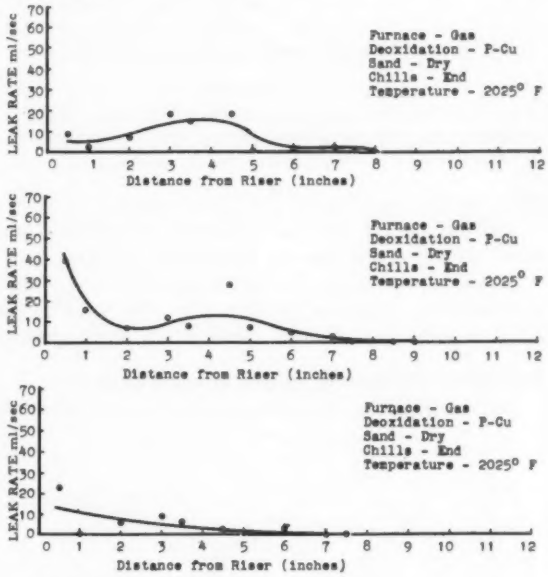


Fig. 14 — Riser size effect upon leak rate. Top — 37 per cent larger; center — 44 per cent smaller; bottom — standard size.

three bars indicates that the sound material extends from the region 8 in. to 12 in. from the riser. The thermal gradients in the bars attain values above 60 F/in. only in this range.

12 in. Bars of Different Thickness

Preliminary experiments were conducted to evaluate the effect of reducing the bar thickness to values

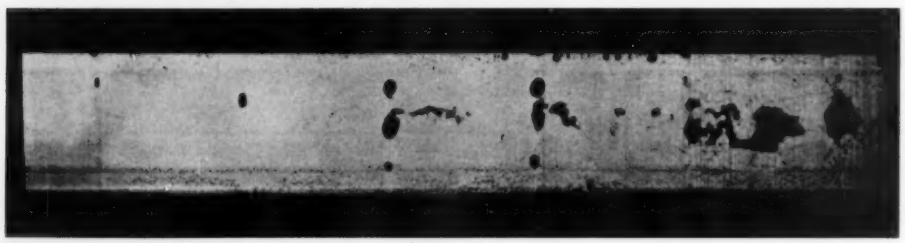


Fig. 12 — Midsection of 12 in. bar poured at 2275 F showing gas porosity, riser end on right.

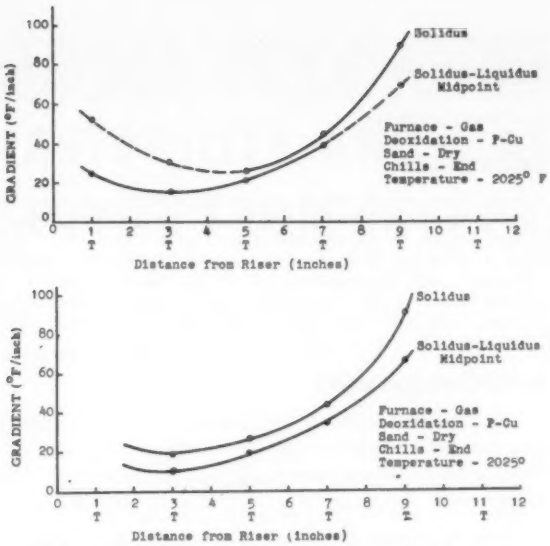


Fig. 15 — Thermal gradients for large and small risers. Top — 37 per cent larger; bottom — 44 per cent smaller.

of 1½, 1, ½ and ¼-in. The ¼-in. bar did not run satisfactorily, and the end of the ½-in. bar did not fill. Since this was a preliminary survey both thermocouple and leak rate data were obtained. As mentioned previously, this required a shift of about ¼-in. away from the centerline for pressure testing, and only the 2 in. and 1½-in. data are therefore considered representative (Figs. 16-18).

The 1½-in. bar showed a slightly lower leak rate than the 2-in. bar, particularly near the riser. This may be due to two reasons, 1) steeper gradient at the riser, and 2) the greater ease of plate like feeding compared to bar-like feeding (in plates, dendrites originate at only two walls compared to four in bars). These bars exhibit leak free regions when a thermal gradient of 60 F/in. is exceeded, in accord with the observations previously described for the other tests.

CONCLUSIONS

1) Pressure tight bars, 2 in. x 2 in. x 9 in. and shorter can be made by proper chilling techniques. This range can probably be extended by modification of the design of the tapered chills.
2) Preliminary experiments in varying riser volume indicated that the thermal gradient was affected for about 4-in. from the riser. Further experimentation employing insulated risers is indicated.
3) In the many different specimens which were tested, sound material was obtained when the thermal gradient exceeded 60 F/in., and unsound material resulted from lower gradients. The only exception to this rule occurred when high pouring temperatures were used, resulting in gassy castings.

RECOMMENDATIONS FOR FUTURE WORK

The data indicate that a thermal gradient of 60 F/in. is required for soundness in 2-in. square bar sections in a variety of mold modifications. The effectiveness of an end chill in establishing this gradi-

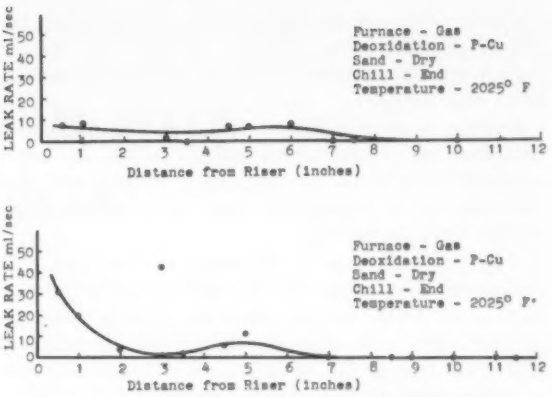


Fig. 16 — Bar thickness effect on leak rate. Top — 1½ in. bar; bottom — 2 in. bar.

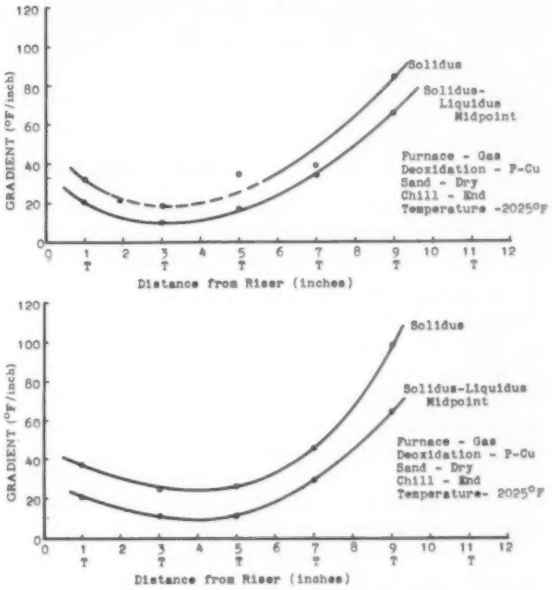


Fig. 17 — Thermal gradients in 2 in. (top) and 1½ in. (bottom) thick bars.

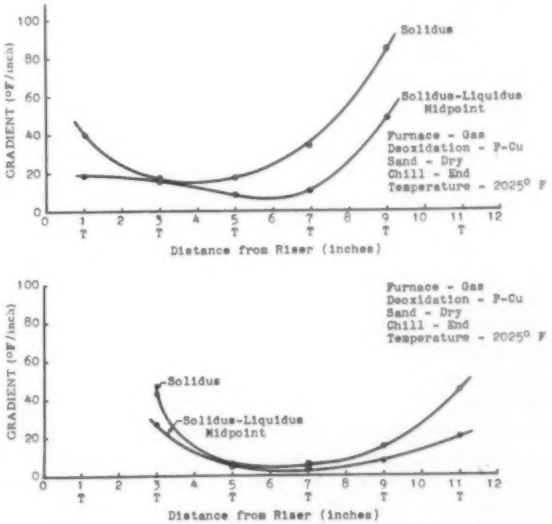


Fig. 18 — Thermal gradients in 1 in. (top) and ½-in. (bottom) thick bars.

ent is for about 4 in. along the bar. The risers employed thus far have provided this gradient for less than 1 in., and therefore unsound material is encountered near the riser.

Further work is indicated using insulated risers. A combination of risers plus wedge chills provides a gradient of 60 F/in. for slightly over three in. The combination of insulated risers with wedge chills should be of importance.

The determination of distances of riser and chill effectiveness for other sections will complete the data needed for mold design. Other bar cross-sections and several plate cross-sections should be investigated. Upon the completion of this work the application to typical castings should be investigated.

The attainment of pressure tight sections in these bars by the selection of the proper thermal gradients indicates possible application of the data to improvement of mechanical properties. It would be interesting to determine improvement in mechanical properties which should accompany the production of pressure tight sections.

REFERENCES

1. Richard A. Flinn and C. R. Mielke, "Effects of Foundry Variables upon Porosity of 85-5-5-5 Bronze," AFS TRANSACTIONS, *vol. 66*, pp. 391-396, 1958.
2. R. A. Flinn and P. K. Trojan, "Pressure Tightness in 85-5-5-5 Bronze," AFS TRANSACTIONS, *vol. 64*, pp. 339-343, 1956.
3. John Kura, et al, "Mechanical and Physical Properties of Three Low Shrinkage Copper Base Alloys," *Proceedings of the A.S.T.M., vol. 58*, 1958.

ACKNOWLEDGMENT

The authors wish to acknowledge the thoughtful and extremely helpful support of the members of the Brass and Bronze Division Research committee and of the AFS Training and Research Institute.

METHOD OF OBTAINING CASTABILITY AND MAXIMUM FIELD SERVICE FROM CAST PRODUCTS

By J. W. Beckham

ABSTRACT

In recent years, foundrymen have become more and more aware of the need, as well as the benefits, of working directly with the designer in creating a cast product to best meet the requirements of both parties. To obtain this mutual goal, the casting design must make the most efficient use of the metal in field use and also have good castability in the foundry. The method of casting design outlined has proved to be a satisfactory engineering approach to obtaining these two desired end results — good castability combined with equal stress distribution on the casting while in field use.

INTRODUCTION

Casting designers and foundrymen are rapidly recognizing that each has basically the same problem in castings whether it is stress concentration due to field loads or strain concentration set up by the cooling of molten metal in a mold. This condition has been aptly covered by Caine[1] in his comparison of stress concentration factors in corner radii of *L* and *T* shapes as related to their thermal gradients. As casting designs usually get more complex than these basic shapes, the writer would like to present a workable method of combining maximum castability with minimum stress concentration in the design of any cast shape.

An interesting fact demonstrated by this method of design is that the designer who works out a casting free from areas of high stress concentration will, in nearly every case, also have a shape that can easily be cast. Since these two conditions are closely related, the need for close contact between design engineers and the foundrymen from the inception of a casting design becomes even more obvious. Too much importance cannot be placed on this point as we are all realizing more and more the importance of communication between designers and foundrymen in formulating the most advantageous design for both.

Some six years ago, the management of the foundry employing the writer, saw the need for close work with the customer on casting design, and set up a separate Casting Design Department specifically for this purpose. This, of course, is an ideal situation, as it enables the foundry to engineer the casting for both maximum castability and minimum stress concentration and deliver it to the customer as a finished package. It should be said here, however, that it is not possible to do this to every new casting design coming into the foundry.

DESIGN PROCEDURE

To start a casting design through such a procedure one must obtain from the customer as much of the following information as is available:

Quantity Involved. This naturally will determine to a great extent the amount of design development.

Time Available for Development. This also will determine whether or not much effort should be spent on design. It must be remembered, however, that in many cases the method described will give faster results than putting an unproved design in the field for lengthy tests.

Direction and Amount of Load. The direction of loading on the part and its approximate magnitude should be carefully determined.

Clearance Conditions. Knowing the casting's environment in the finished product and including necessary operating clearances.

Weight Limitation. This is an important factor in most designs because it has considerable bearing on the casting cost, as well as on freight costs per unit. A good casting design utilizes all its metal efficiently to give maximum strength at the least weight.

The answers to these questions will then serve as a guide in determining the extent of design work possible or feasible on any one part.

After obtaining the above mentioned information from the customer and determining the extent of work required on any particular job, it is then possible to proceed with the design. Usually, a certain amount of free hand sketching, done either with the customer's engineering staff at the time of the initial contact or later after the information has been received, will help formulate a rough picture of what is needed. At this stage of design it is beneficial, at times, to also make up some kind of wooden or clay model of the ideas suggested. This does not have to be an actual scale model done by a professional, but can merely be a means of working in three dimen-

J. W. BECKHAM is Supt. Rsch. and Design, Texas Foundries, Lufkin.

sions to help envision a shape difficult to put on paper.

Calculations Necessary

Some mathematical calculations are also needed in formulating the initial design. These, however, can easily become complex when one tries to figure stresses on such odd shapes as are inherent in products of the cast process. To help make this initial slope of the design easier, however, Caine[2] recently has worked out a set of tables which can be beneficial. These tables give design information such as moment of inertia, section modulus, and radius of gyration on various sizes of tubulars, Omega, U and C sections all of which can easily be cast.

This information can be helpful when used as a guide in selecting an appropriate size and shape for use in designing a cast part, especially if one does not often use the complex formulas needed for figuring these properties.

Next in line in this design program is the preparation of a drawing of the finalized design giving enough information from which to make a pattern. In most cases the sample can be made from a master pattern. This will cut down the initial pattern cost, and makes it possible to change the pattern with a minimum of expense if it is found necessary. The master pattern when made is then turned over to the foundry for producing samples. This gives them an opportunity to determine the best gating and finishing methods to be used on the casting.

The finished sample is then thoroughly checked by magnetic particle inspection for any flaws. Facilities are also available for taking radiographs of the sample parts with cobalt 60 or cesium. Part of the inspection also is a layout of the sample to check its functional dimensions.

If the sample passes these checks, it is then fully machined if not used as a rough casting, giving the machine shop an opportunity to check finish allowance, chucking lugs and all other points with which they are concerned.

The machined part is now ready to put in the assembly in which it functions and the design analyzed by use of experimental stress analysis. It is important to run this analysis on a fully machined casting, as many times a good casting design can be ruined by bad machining practices, the worst offender being sharp corners.

STRESS ANALYSIS

Two methods of stress analysis are most commonly used in checking the finished casting. The initial use of brittle lacquer will locate the areas of high stress on the part and their approximate magnitude. This test can either be run in the field under actual conditions or in a laboratory under simulated loadings. Tests made in a laboratory will give more accurate results, however, if field loading conditions can be reproduced.

Having located these areas of highest stress on the casting, it is possible to then apply electric strain gages in these locations to obtain more accurate readings of the strain.

A more detailed description of the procedures used in making the tests described above is given in a paper[3] presented at the 1955 American Foundrymens Society Convention by the writer.

The information obtained by such tests is invaluable in determining the final design of the casting. If this first design is shown to be highly stressed in any one area, the shape can be changed to eliminate this condition using the overall stress picture as indicated on the part by stress analysis.

Redesigned Brake Shoe

To demonstrate specifically how this procedure works, the following example of the redesign of a brake shoe is submitted. The casting shown on the left in Fig. 1 had been made in this design for a number of years. In an effort to reduce the weight of the axle assembly using this brake shoe, the manufacturer was considering the use of a lighter fabricated type as used on some of the competitive axles. To prevent such a change, it was necessary to produce a cast part weighing no more, and having equal or greater strength, than the fabricated brake shoe.

The first step in formulating the new design was a stress analysis check of the original brake shoes in the complete axle assembly. Figure 2 shows the test setup using one hydraulic ram to expand the shoes and another to simulate the circular wheel loading on the brake drum. This test pointed out the areas of highest stress and their relation to lower stressed areas on the brake shoe. At this time, some of the fabricated shoes were also evaluated by stress analysis in the same setup. With this information, it was then possible to reduce the weight of the original design 25 per cent, and eliminate the area of high stress on

Fig. 1 — Trailer brake shoe. Original design is on the left, and redesign is on the right.

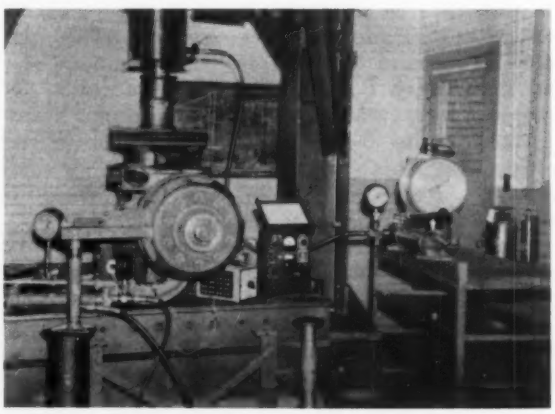
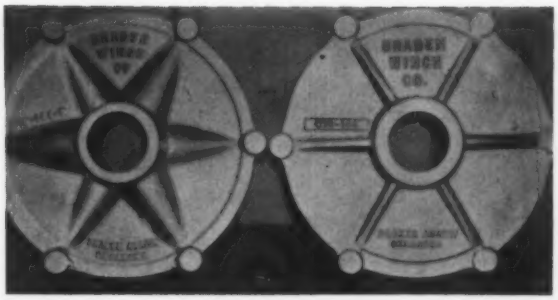


Fig. 2 — Laboratory setup for experimental stress analysis of brake shoes.



Figs. 3 and 4 — Winch housing end plate, top and side views. On the left of each figure is the redesign, and on the right is the original design.

the rib and in the notched section of the brake shoe's inner flange.

The new design is shown on the right in Fig. 1. Results of the stress analysis made on this redesigned shoe showed that in addition to reducing the weight 25 per cent, it was 1.94 times stronger than the original. This added strength was obtained merely by taking out the notch and rib on the inside flange and casting this surface with an uninterrupted curve. Small ears extending from both sides of this inner flange are drilled to serve the same purpose as the recess and rib used on the original design. Another advantage of the elimination of this high stressed area is the freedom from cracks and feeding problems formerly encountered there.

Winch Housing End Plate

Figures 3 and 4 show the top and side views of two castings used as a winch housing end plate. The original design on the right used opposed ribs across a flat plate to strengthen the hub. The junction of these opposed ribs across the plate created heavy sections in the casting that were not only difficult to feed but were slow to cool, thereby causing excessive cooling strains in the casting. Cracks on the outer edge of the casting were the natural outcome of this condition. The use of a corrugated plate section, as shown on the casting at the left in Figs. 3 and 4, eliminated the hot spots created by the opposed ribs solving the foundry problem.

In doing this it was also possible to reduce the weight 25 per cent, and increase the strength by distributing the concentrated stress that was created on the rib over a much wider area on the corrugation.

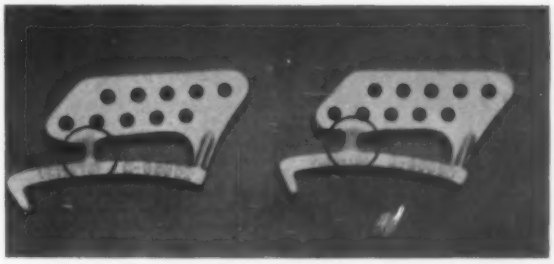


Fig. 5 — Plow sweep bracket. Original design is on the left, and redesign on the right.

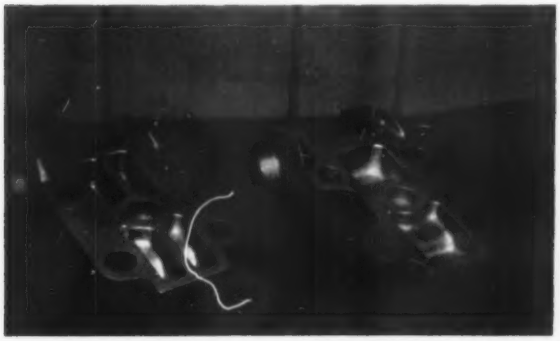
Other Examples

Figure 5 shows a plow sweep bracket (left) which was failing in the strut (circled area). By a slight change in the angle of this strut and the use of larger fillets, the strength was increased 57 per cent with no noticeable weight increase (right).

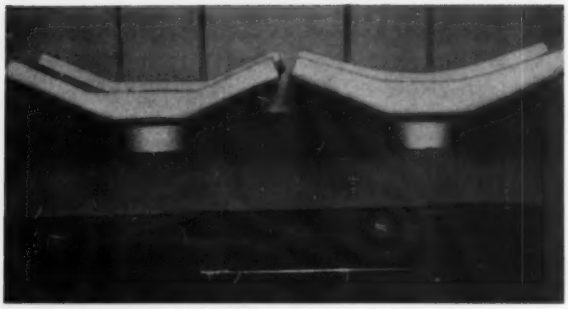
Figures 6 and 7 show the top and bottom view of a trailer axle seat which, when redesigned, maintained equal strength with a weight reduction of 19 per cent and a nearly equal cost reduction. This also made a much easier job for the foundry.

Figures 8 and 9 show two views of a stalk cutter blade hub. The casting on the left was yielding in service on the ribs at small radius. Addition of a little height plus elimination of the high stress area on this rib doubled the castings strength with only 7 per cent weight increase (right).

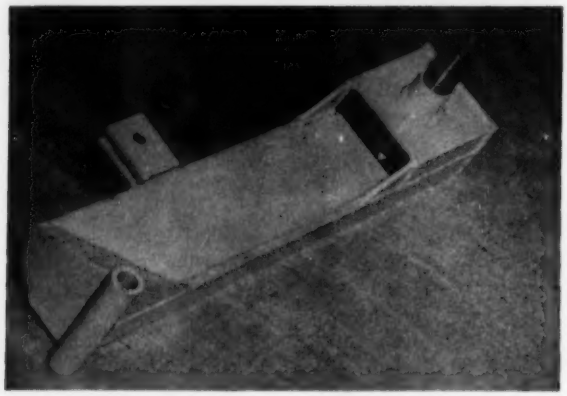
Figures 10 and 11 are of a weldment and the composite weld conversion. This serves as a wheel arm support on a 15 ft mower. Four of these parts are used per unit—two right and two left. The steel casting was designed to permit its use either as a

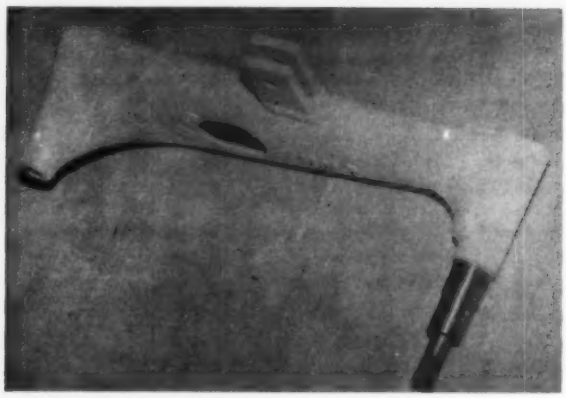


Figs. 6 and 7 — Top and bottom views of trailer axle seat. Original design is on the left, and redesign is on the right.



Figs. 8 and 9 — Top and side views of stalk cutter blade hub. Original design is on the left, and redesign is on the right.





Figs. 10 and 11 — Original fabrication (left) and composite weld (right) for a wheel arm support for a 15 ft mower.

right or left support. This is accomplished by welding the two ears on one side or the other. The spindle is turned from bar stock and also welded on. This design gave added strength, better appearance, at one third less cost.

CONCLUSIONS

The writer would like to emphasize the following points brought out in this paper.

1) Close contact between the foundry and the designer concerning any casting design or redesign from its inception will result in the maximum benefit to both parties.
2) A casting design free of unequally high stress concentrations in field use is, in nearly every case, one that can easily be cast in a foundry.
3) The use of experimental stress analysis in developing any casting design will give the designer the overall picture of stress relationship on the part. This, in turn, makes possible the design of a casting engineered for maximum field service, castability and minimum cost.

REFERENCES

1. J. B. Caine, "Interrelation Between Stress Concentration and Castability," A.F.S. Transactions, *vol. 67*, 1959.
2. J. B. Caine, "Design Properties of Cast Section," Part 1 and Part 2, Report to Texas Foundries Inc., to be published in 1959.
3. Joe W. Beckham, "Use of Experimental Stress Analysis as a Casting Design Tool," AFS Transactions, *vol. 63*, 1955.

PINHOLE OCCURRENCE IN MALLEABLE CASTINGS

bonding clays as cause

By D. R. Jones and R. E. Grim

ABSTRACT

Pinholes in malleable castings, it is the conclusion of the authors, are often caused by the evolution of water vapor from certain clay bonds in green sand molds when heated above 212 F by molten iron. Research on the problem was done after foundry experience revealed that pinholes occur less often when illite rather than other clay bonds is used. The amount and rate of water vapor evolution from each of four different clay bonds when heated above 212 F was recorded by laboratory methods.

The difference, it is believed, explains why the kind of clay bond used has such an important effect on the occurrence of pinholes. Theories on the formation of pinholes in steel castings are presented from the literature as possibly analagous to the mechanism in malleable iron. Practical foundry tests to support the laboratory investigation are also given.

INTRODUCTION

The occurrence of pinholes on or below the surface of heavy-sectioned malleable iron castings after annealing is, and has been, a costly problem to some malleable iron foundries. Some of these malleable foundries have successfully reduced the occurrence of pinholes by changing the clay bond. This paper explains why this change in bonding clay is effective in eliminating pinholes.

Users Recognition of Clay Effect on Pinholes

About four years ago at a meeting of malleable foundrymen the question of pinholes was raised. It was disclosed that several of the foundries represented had seldom if ever experienced pinholes, whereas other foundries in the same area producing similar castings were periodically plagued with pinholes. The fact that the foundries without pinhole problems each used an illite clay bond was not recognized as significant at that time.

One of the foundries (Foundry A) was experiencing a particularly heavy siege of pinholes. To determine whether their problem had any relation to conditions elsewhere, patterns and enough sand to make test molds were delivered to one of the foundries (Foundry B) that had reported no pinhole difficulties. Molds made with Foundry A's sand were poured off with metal from Foundry B. The castings shaken out of these molds contained pinholes. Similar molds made with Foundry B's sand produced castings with no pinholes.

The procedure was reversed. Sand from Foundry B was delivered to Foundry A. When metal from Foundry A's air furnace was poured into molds made with sand from Foundry B, no pinholes appeared on the castings. Since the sand and not the metal made the difference, Foundry A proceeded to duplicate Foundry B's sand. One ingredient at a time was changed with no benefit until the clay bond was changed to illite. This proved to be the critical item.

By changing only the clay bond, other foundries were also able to rid themselves of pinholes. At that time no one knew why the bond clay made a difference.

Thermal Analysis of Clays

A set of thermal curves was made at the Geology Dept. at the University of Illinois to determine the difference if any in gas evolution from the bonding clays in question when heated. Data indicated that the gas that creates pinholes could be caused by adsorbed water, which is released by some clays when heated to about 212 F or slightly above.

Apparatus and Procedure

The apparatus used to measure the rate and amount of evolution of water vapor when clays are heated is illustrated in Fig. 1.

The clay is heated in a glass or quartz tube enclosed in a small furnace. The tube is open at the ends, and a stream of nitrogen previously dried is passed across the hot clay under pressure. The nitrogen carries along the water vapor.

The nitrogen with the vapor then passes through a granular water absorbent, which picks up the water and causes a heat of wetting reaction. The amount of heat is dependent on the amount of moisture pickup. There is a differential thermo-couple junction at each end of the adsorbent and the temperature difference is plotted against the temperature of the clay.

The temperature difference gives a measure of the amount of water vapor evolved and, since it is plotted against furnace temperature, shows the rate of gas evolution as well as the amount. The depth of the dips of the curves indicates the amount of water vapor, and dip sharpness shows rate of gas evolution.

D. R. JONES is Asst. Sales Mgr., Illinois Clay Products Co., and R. E. GRIM is Professor of Geology, University of Illinois.

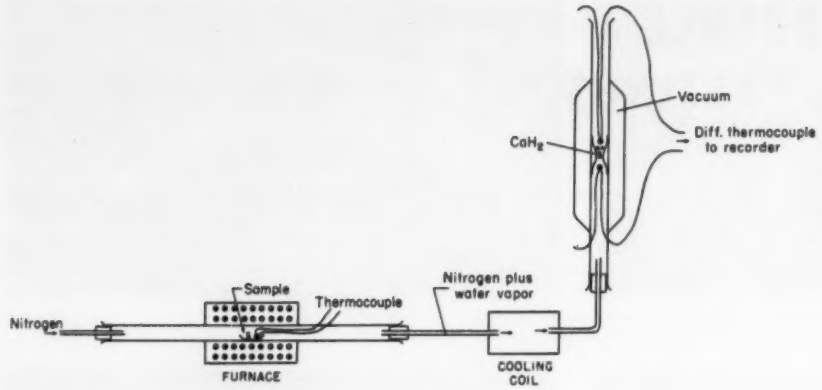


Fig. 1 — Schematic drawing of laboratory apparatus used to determine quantity of water vapor evolved, and the rate of evolution, from bonding clays.

The curves in Fig. 2 show the slight and gradual evolution of water vapor from illite, and the large expulsion of water vapor at low temperatures from the bentonites. This, the authors believe, is significant.

The samples tested were air dried. On air drying the bentonites retain considerable adsorbed water between unit layers of montmorillonite, their clay mineral compound, whereas fire clay and illite have only a little pore water and no adsorbed water similar to that in the bentonites.

In a green molding sand, the pore water in the illite and fire clay would be easily removed. In the bentonites, pore water would also be present, but there would be additional water between the unit layers which would be suddenly expelled when metal is poured into the mold. The adsorbed water is expelled abruptly at about 250 F.

Foundry Test

To prove the data, a test was made in a malleable iron foundry which had experienced pinholes on certain castings, and eliminated the pinholes by substituting illite for another bonding clay.

A pattern for one of these castings was selected and two molds were made. The cope and drag pattern surface of each mold was faced with southern bentonite bonded sand. One of the molds was torch

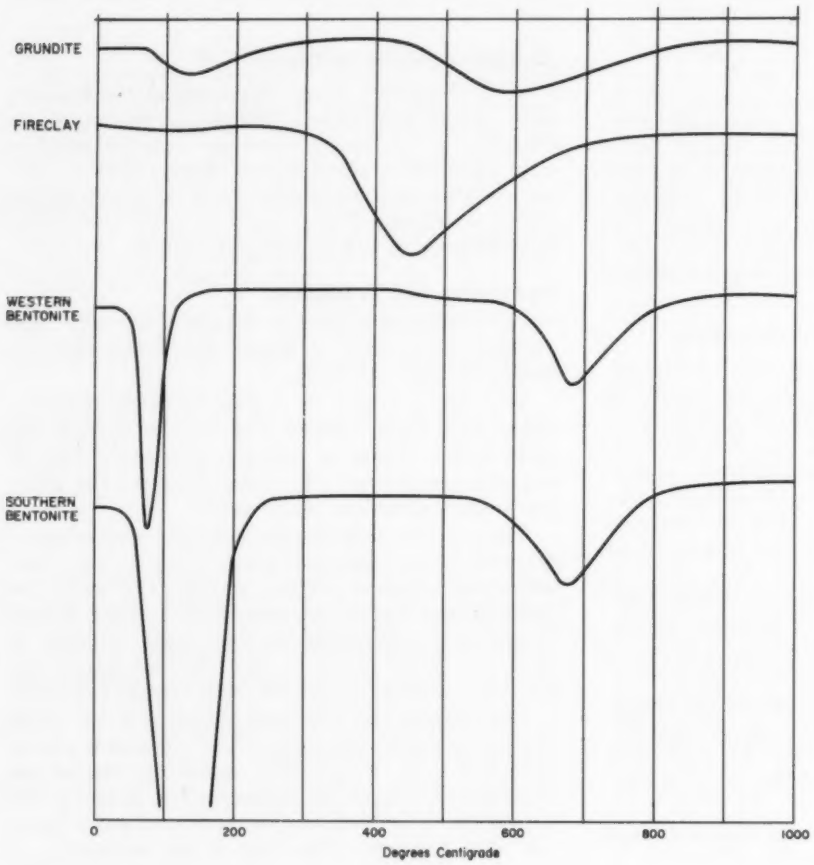


Fig. 2 — Thermal curves of bonding clays showing variations in water vapor evolution.

dried on both cope and drag surfaces. It was impossible to determine the temperature reached at the mold surfaces. A thermocouple placed ¼-in. back from the mold surface indicated a temperature of only 157 F during the torch drying. Since the temperature of the flame was over 1000 F it is safe to assume that all of the free water was removed.

It is reasonably certain, on the other hand, that none of the chemically combined water was removed, because when the torch was left in one place too long the sand surface would lose its bond and crumble indicating that the clay was calcined. The mold that was dried for this test and used did not reach the crumbly state.

The other mold was not dried. Both molds were poured off with iron from the same ladle within 10 min after being closed. The castings made in the flame dried mold, Fig. 3 (right), showed no evidence of pinholes after annealing, whereas the castings made in the undried mold produced pinholes (Fig. 3, left).

This work confirmed a test made by a large national concern that has made a study of pinholes in malleable iron and aluminum castings. This company oven-dried a bentonite-bonded mold prior to casting malleable iron, and was able to eliminate most of the pinholes. The incidence of pinholes is greater as the section thickness of the casting increases because of slower solidification of the iron. Also, pinholes are more apt to appear at reentrant angles of the casting where the adjacent mold surface is surrounded by iron to a greater extent than on straight surfaces.

The previously mentioned company makes malleable castings up to 5 in. in thickness, and their pinhole problem is consequently more acute than would be expected in more typical malleable casting production. They were able to eliminate pinholes on all but the heaviest sectioned castings when an illite bonded sand was used. When using other clay bonds they found it necessary to increase the seacoal addition up to 12 per cent as the section thickness of the casting increased.

It was found that whereas it required up to 12 per cent seacoal to react with the extra volume of water vapor given off by sand bonded with bentonite, the normal amount of seacoal present in the sand, say 4 per cent, was sufficient when illite was used. An

Fig. 3 — Complete and fractured casting with pinholes (left, top and bottom) made in undried molds, and castings free from pinholes (right, top and bottom) made in predried (flame dried) molds.

explanation for the usefulness of seacoal in this respect will be presented later. This foundry also found that molds made by the CO_2 process produced malleable castings free from pinholes.

This company concluded that pinholes are caused by entrapped gas in the metal. They determined that slightly more than half of this gas is present in the metal before it is poured into the mold. The rest of the gas, they determined, comes from green sand molds. The gas that is present in the metal before it enters the mold will not usually produce pinholes unless it is increased by gas from the mold.

Therefore, if water vapor from the molding sand is sufficiently low in volume such as in dried molds, CO_2 process molds, or illite bonded molds, pinholes will not usually occur. It also was determined that if hydrogen gas is removed from the metal before it is poured into the mold pinholes will not appear in the casting.

PINHOLE FORMATION IN STEEL CASTINGS THEORIES

An explanation for the appearance of pinholes in steel castings that is available in the literature seems logically analagous, and is presented here to give a fuller picture of the possibilities for pinholes occurring in malleable castings.

According to Sims and Zapffe,* when steel is poured into a green sand mold steam is generated. Part of the steam escapes through the facing sand, and some of it reacts with the hot steel thus:

$$H_2O + Fe \longrightarrow 2H + FeO$$

The FeO is found as a layer of scale on the surface because of its slow rate of diffusion. The hydrogen readily diffuses into the steel and raises the hydrogen content of the steel. The hydrogen then combines with the FeO to form a small bubble of water vapor, which grows when more hydrogen diffuses into the bubble.

> "When the growth of the advancing bubble slows down sufficiently because of depletion of hydrogen in the surrounding metal, the crystals seal off the passageway and a pin-hole remains.
>
> "Steels which develop pin-holes when cast into certain green sand molds may be free of pinholes when cast into well-dried molds."

According to Savage and Taylor,† pinholes in steel castings are caused by the reaction between dissolved carbon and oxygen from the iron oxide that is found at the metal-sand interface. Their contention is that carbon rather than hydrogen combines with oxygen and forms carbon monoxide with sufficient pressure to form gas bubbles in liquid steel.

Seacoal Effect

Strangely enough, in malleable foundries, seacoal in the sand, although a heavy gas producer, has a tendency to decrease rather than increase pinholes. An explanation for this is that the carbon in seacoal has a greater affinity for oxygen than does iron; therefore, water vapor in a green sand mold reacts with the seacoal to form CO rather than with the iron to form FeO.

The FeO is the basis for the reaction with hydrogen gas to form pinholes, as suggested by Sims and Zapffe; and FeO also has to be present to combine with the dissolved carbon in the metal to form carbon monoxide pinholes, as suggested by Savage and Taylor. Seacoal would prevent either of these taking place if used in sufficient quantity.

The explanation for the action of illite clay, it is believed, is that when it is used to bond the sand the evolution of water vapor is sufficiently slow so that most of the steam can be expelled through the sand rather than react with the iron to form FeO.

CONCLUSION

Pinholes may occur in certain malleable castings when the metal is cast in green sand molds. This possibility is reduced when the amount of water vapor available for reaction with the hot metal is minimized. It has been demonstrated that certain clay bonds used in green sand molding emit a smaller volume of water vapor and at a slower rate when heated than other clay bonds. In many cases pinholes are avoided by using these clays.

When water is removed from the mold entirely by heating prior to pouring metal into it, the absence of water vapor for a reaction insures a pinhole free casting in most cases. Further, when seacoal is used in sufficient quantity in green sand molds, the possibility of pinhole formation is reduced no matter what clay bond is used.

Therefore, a reduction in occurrence of pinholes in malleable castings can be obtained by:

1. Pre-drying the mold.
2. Increasing the seacoal content.
3. Removing hydrogen gas from metal prior to pouring.
4. Selecting a clay bond with a low water vapor evolution.

*C. E. Sims and C. A. Zapffe, "The Mechanism of Pin-Hole Formation," AFS TRANSACTIONS, *vol. 49*, p. 255, 1941.

†R. E. Savage and H. F. Taylor, "A Thermodynamic Study of Pinhole Formation in Steel Castings," AFS TRANSACTIONS, *vol. 58*, p. 393, 1950.

INDUSTRIAL ENGINEERING FOR THE SMALL FOUNDRY

a practical approach

By F. E. Noggle

ABSTRACT

Webster defines *practical* as given or disposed to action rather than to speculation. Therefore, this is limited to an exploration of a work measurement plan that will lend itself to immediate application, while the broader theoretical aspects of the subject will be largely ignored. Within the limits of practicability a further limitation will be observed, that is, all recommendations and conclusions will be made with a view to practical application in the small, as opposed to the large, foundry. For the purpose of this discussion, the small foundry is defined as one which has approximately 50 to 100 employees.

INTRODUCTION

The term *industrial engineering* covers a wide variety of activities in the management of a business. It includes planning the flow of work through the plant, time and production studies, planning plant facilities to increase efficiency, setting up wage schedules, conducting safety campaigns, determining product cost and cost control and estimating, to name some of the more common types of activity. However, the ultimate general goal of all these activities is to control and/or lower costs.

It is this general goal which will be kept in mind in this discussion, so that for the present purpose industrial engineering shall be defined as fact gathering, fact analysis, system development and application aimed at controlling or lowering costs.

One further question that presents itself is—wherein do industrial engineering plans for the large foundry and the small foundry differ? It is important to realize that the difference lies not in their respective needs for such plans, as it is just as important to the small foundry as to the large foundry that costs be controlled at their practical minimum level. Rather, the difference lies in the availability of personnel to carry on the work of industrial engineering.

In a large foundry, a typical industrial engineering department may consist of a time-study department of five or six standards men, a work simplification or methods department, an estimating department and a production control and planning department. These all report to the industrial engineer, who in turn reports to the works manager. Obviously, departmentalization on this scale is out of the question for the smaller foundry. A plan of practical industrial engineering for the smaller foundry must, therefore, be premised upon the employment of minimum personnel with specific individuals assigned to multiple duties in maintaining the system.

F. E. NOGGLE is with Westover Corp., Milwaukee.

PRESENTATION METHOD

Keeping the goal of practical application in mind, the plan must be presented in the most concrete terms possible. For this purpose, let us postulate a "typical" small foundry, based upon knowledge and experience with smaller foundries as they actually exist. In its general outline, it will be found that this typical small foundry presents the following picture.

Fewer than 100 are employed in this foundry. The company is getting along, but many times finds it difficult to obtain orders. Often orders will be lost to competitors by margins of a few cents per casting. The profit and loss statement does not show a good margin of profit, in fact losses occur periodically. Personnel relations are fair, but employees in general are not entirely happy. They ask for larger raises than business conditions seem to warrant. The scrap picture is not bad, but definitely could be improved.

Matters come to a head after several apparently good orders are lost to competitors by narrow margins. At this point the manager decides to find out what can be done about the situation. He may more or less consciously formulate the problem into the following questions:

1) How can we lower the production costs?
2) How can we pay more money to labor and still remain in a competitive position pricewise?
3) Can we somehow improve the estimating practices to attract more business, without lowering our profit?

FACT-FINDING

Report and Recommendations

Since this foundry is without an industrial engineering department, it is necessary to call in a qualified industrial engineer to make a survey of existing conditions, and to recommend a plan which attempts to realize the goals of cost control and of cost reduction which are implicit in the three questions above.

The engineer who is called in will know from experience that the work ahead can be roughly divided into three phases. The first of these is a survey de-

signed to ascertain all the facts which are needed to clearly define the specific problems, and to define the areas in which standards of performance (which are basically the means of controlling costs) should be set up. The outcome of this survey will be a report in which problems are clearly defined and a specific system of cost control is outlined.

The second phase is setting up the system which has been evolved to meet this company's problems. It includes the gathering of standard data upon which performance standards will be based, and the training of company personnel who will be responsible for maintaining the cost control system after it has been installed.

The third phase of activity is maintenance of the system, including a method of performance reports to management. This third phase of the system is carried on by company personnel who have undergone the training of phase two.

What, now, are likely to be the contents of the industrial engineer's report after he has completed his fact-finding survey? Since our hypothetical foundry is "typical," the engineer's report is likely to include the following points under the headings of Wage Payment, Estimating Practices and Production Control.

Wage Payment

1) About 30 per cent of all labor put in is covered by incentives.
2) The average productivity of the employees who are on incentive is only approximately 90 per cent of the nationally accepted norm, although their earnings are 150 per cent to 200 per cent of the operator's base rate as it exists in this foundry.
3) The type of incentive plan in use is a piecework system. Piece prices are determined by comparison and/or a direct time study.
4) Production recording is far from accurate, especially in the matter of recording delays and other time allowances.
5) Counts of pieces produced are fairly accurate, but earnings are greatly affected by guessing at the length of delays.
6) Distribution of wages is causing labor relations problems. This is shown in Fig. 1, where it may be seen that actual earnings of less skilled occupations are equal to and even higher than the earnings of those in jobs requiring more skills. This situation exists because piecework prices have been established for operations such as squeezer molding and blower coremaking. The molding of loose work, floor molding and similar activities have been left on daywork.
7) The present system is so shot through with uncertainties and guesswork that it does not actually provide management and supervision with a means of controlling labor costs. Much needless waste is not even guessed at until it is demonstrated by a poor profit and loss statement.

The engineer's recommendations under this heading are:

1) Replace the present piecework system with a measured time system based on standard data.
2) Extend the incentive coverage from the present 30 per cent to at least 80 per cent of all labor using the measured time system, for the purpose of gaining better control of labor costs, gaining better distribution of wages to eliminate grievances and labor relations problems and to lower labor costs through higher productivity.
3) Establish a timekeeping function for the purpose of accurately recording delays and other off-standard time. This same timekeeping function will also perform a certain portion of the payroll calculations.
4) Develop a system of reporting vital information to supervision and management for the purpose of readily detecting waste and controlling labor costs.

Estimating Practices

Under this heading the engineer points out:

1) Estimates are made by comparison with similar castings. Actual past performance is here considered the substantiating factor.
2) Overhead costs are applied on a department-wide basis. For example, the same overhead is applied to core blowing and bench coremaking.

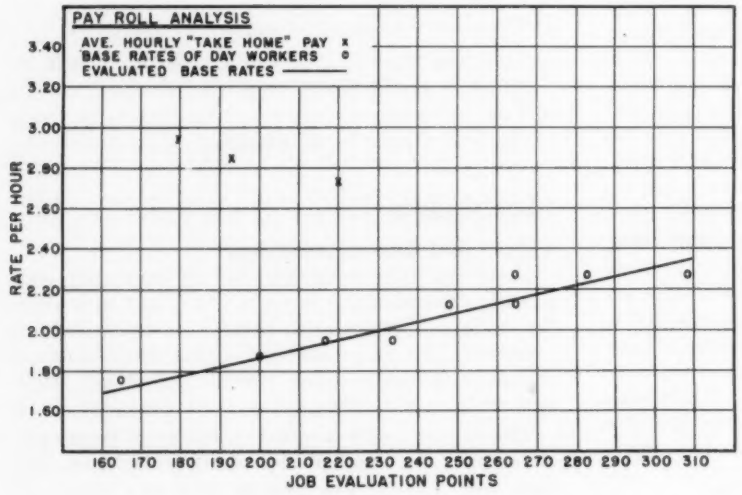


Fig. 1 — Distribution of wages causing labor relations problems. Actual earnings of less skilled occupations are equal to and even higher than those jobs requiring more skills. This is because some operations have piecework prices established, while others do not.

3) Cleaning costs are calculated at a fixed rate per pound for castings.

In making his recommendations the engineer will aim at correcting certain serious costing errors which result from present practices. For example, not only can comparisons with similar castings be misleading, but actual past records of performance on those castings may lead to unbelievably high labor costs with resultant noncompetitive pricing. At first glance this may appear a paradox, since what can be more accurate than an actual record of production? However, the fact is that at best such records show only what was done and not what could or should have been done in production.

At worst, the record may not even show what was done. It may not show what difficulties were encountered, whether the sand was too wet or too dry, that the cores were not ready and the molder waited until they were delivered, or 101 other things which make jobs take longer than they should. Thus, the estimator may find himself in the position of attempting to use an unknown quantity as the basis for comparison in his own important task of arriving at prices that will bring business into the plant.

Case History

The degree of error in estimates and quotations based on past performance can be shocking when it is finally brought to light. To illustrate this, consider the case of an actual company which is on record. Over a period of a year overall performance had been accurate within 5 per cent of estimated time on operations. However, standard data for incentive application had been developed, and it was decided to take a specific job and find out how the estimate and the new standard compared. The estimate, based on past performance on various jobs, was given as 141 hr.

However, the new performance standard allowed for only 97 hr, or only 65 per cent of the estimate. Needlessly, the superintendent ridiculed the lower figure, since he felt he could depend upon past experience. However, when this job was put on incentive based on the new standard, it was actually carried out in only 84 hr. Moreover, performance continued at approximately the same greatly improved rate of productivity wherever the new standards and incentives were applied. Similarly unrealistic estimating is exceedingly common wherever the foundry depends upon past performance as a measuring stick.

Obviously, if past performance was poor, it will only result in continuance of needlessly high cost when it is followed as a model. At the same time, past performance times may have been based upon methods or equipment that have now been replaced by more efficient means which are not, however, taken into consideration, and therefore do not actually bring about the cost savings for which they were intended. Thus, we find that the engineer's report contains these recommendations under this heading:

1) Collect costs by cost centers.
2) Establish a normal capacity for each cost center in terms of measured time.
3) Calculate a costing rate per unit of time for each cost center involved.
4) Develop a system of reporting variances from the standard for management for the purpose of controlling manufacturing costs.

Production Control

The final heading of the engineer's report shows these facts:

1) Delivery dates are frequently missed because of lack of sufficient information regarding progress of production.
2) Customers' telephone inquiries regarding items on production are difficult to answer because production information is not centralized, but is scattered through various departments.
3) Frequent errors in production records are caused because records are kept in various places.
4) Losses frequently occur because of overrun on orders.
5) Losses also occur because of lack of coordination, especially between core room and molding departments. These losses consist of lost molding times when cores are not ready on time, and of broken cores caused by storing and re-handling when made too far in advance.

The engineer's recommendations under this heading are:

1) Centralize in one office all records pertaining to production.
2) Improve coordination of production, again by centralizing sufficient information in one place.
3) Develop an integrated data processing system which will reduce errors and at the same time reduce clerical work.
4) Tie in workers' incentive payments with quantities on order to prevent unauthorized overruns.
5) Install some type of visual record showing status of orders so that pertinent information regarding progress is readily available.

SETTING UP THE COST CONTROL SYSTEM

Having ascertained and analyzed in his report problems which are involved, the industrial engineer is now ready to enter the second phase of his work. This phase is the development and installation of a system based on his recommendations for overcoming the problems.

Basic to his thinking must be two important facts. First, this smaller foundry can no more afford to ignore a situation that prevents control of costs, leads to noncompetitive pricing and poorly coordinated, wasteful production methods, than a larger foundry can. On the other hand, unlike the large foundry, the smaller company cannot afford to hire a staff of highly skilled engineers to maintain the new cost control system. This means that the outside industrial engineer must now train a group of selected company personnel so that they will be able to carry out the proposed system without further outside help.

The training program will involve three groups of personnel:

1) Those who will make studies and develop work measurement standards.

2) Plant foremen who will have direct control of labor costs.
3) A selected group of workers who will be taught to understand the workings of the new incentive plans.

Training of Standards Men

Personnel who will be trained to develop and maintain the cost control system must be picked with care. Certain psychological tests of aptitude and interests are available which can assist in selecting qualified people. This test should be given to enough persons so that there can be a selection of individuals who are to receive time-study training. At the end of the training session a final group will be selected who are to do the actual development work.

It may well be that only one or two qualified time-study men will be needed to maintain the system after it has been developed. If more men were trained and used in development, it is not necessary for them to remain as white elephants in the standards departments, since they will be highly qualified for supervisory positions in the organization, such as in production control or as supervisors, foremen or estimators.

To educate the selected group in problems of time study and methods of developing standard data, about six weeks of intensive training are required. In this time the group will learn to read a stop watch accurately, to performance rate operators, as well as learn how to establish allowances for off-standard time properly and to analyze methods. They will learn the basic problems of standard data development, as well as something about work simplification. While this course of training will not turn out accomplished industrial engineers, it will place the men involved in a position to start actual development of standard data under the guidance of an instructor.

Supervisory Training

The main purpose of supervisory training is to teach personnel how to use the labor cost control tool which will later be placed in their hands, since the main purpose of the incentive system will be to lower and control labor costs not simply to pay more money to workers. These supervisors should learn enough about time study and standard data to gain the understanding which will result in confidence in the new system as it is being developed. They need a working knowledge of standards so that they can understand the effect of methods and methods changes on standards, and so that they can readily answer questions asked by workers.

In the smaller foundry it is advisable to have supervisors know the principles of work simplification. They can gain practical experience in this phase of the program during the training courses under the guidance of the industrial engineer. Since the standards department of a small foundry is seldom in a position to initiate and carry out work simplification projects, this aspect of supervisory training becomes quite important, and much can be accomplished through the men who are on the spot where actual production is in operation.

Worker-Training

The training course for workers is aimed at giving them an insight to standard data, how it is developed and how job standards are factored from data. These workers should learn enough about time study to understand that performance rating can be reasonably accurate when the time-study man has had proper training. Such insight and general understanding is necessary, since it brings about faith and confidence in operation standards and furnishes background which enables workers to discuss their problems intelligently.

Selecting and Planning the Project

At the outset of the program all personnel involved, including supervisors, foremen and workers, should be made fully aware of what the project will be, what management plans to do and why it intends to do it. It should be stressed that management wants both to bring about more equitable distribution of wages, and to provide an incentive opportunity to more workers. It should be spelled out that this will result in better relations through eliminating the causes of grievances. Mention should also be made of the need for lower labor costs and for more efficient control of these costs in order to improve the company's competitive position.

The decision as to where to begin in the actual development of standard data must be based on careful consideration as to which department or operation should be studied first. In making this decision, it must be remembered that the time-study men involved will be inexperienced. Therefore, an operation should be chosen where the elements of the operation follow a fairly standard sequence, and where the majority of these elements are of sufficient duration so that reading the stop watch will not be difficult.

It is also important to select an operation where substantial savings are likely to result, whether because of the large number of workers involved, or because the operation is known to be a bottleneck and increased production will benefit other operations as well.

Getting Started

Having trained time-study men, and having selected a logical department or operation as a starting point, the next step is the actual work of developing standard data. It is possible at this point to go far astray from what is practical, by attempting to go to the extremes that are represented by ideal projection. It is far more important in getting started to aim at definite improvement, even though room for further improvement may still remain.

In the matter of methods, for example, the time required to carry out a complete methods project may result in long delays due to an insistence upon having only the best methods before developing data and initiating incentives. Savings which could be accrued from incentive application would be lost during the prolonged time the methods project was in progress.

It is far more practical to adopt the view that work simplification and methods analysis is a project

separate from incentives, and should continue year after year. Then, when methods changes are made standards can also be revised to obtain the savings which result from the further methods improvements.

However, minor methods changes will need to be made before the development of standard data is undertaken. For example, inconsistencies between individual operators must be eliminated so that each person is performing the operating in practically the same manner. If this is not done it becomes impossible to correlate data from time studies into standard data charts.

For example, in bench coremaking the placement of core racks may vary at different benches. One coremaker may only have to turn around to place his cores on a rack, while another may have to walk several feet to do this. In this case appropriate steps must be taken to place racks in the same relative position to each bench before standard data can be developed.

Similar inconsistencies between the methods used by individuals may also be found in operations such as riddling sand, or within the walking distances required for obtaining facing sand or cores in a slinger molding department. Such methods improvements can be undertaken after one study, and without undue delay.

Inadequate Information

Another major pitfall which must be avoided in the development of standard data lies in an inadequate descriptive write-up of the operation, the department, the methods and materials used. Unless this descriptive record is as complete as possible in all details, it may prove impossible to maintain the cost control system efficiently after it has been installed.

This is true because changes in methods, materials, layout, equipment or work sequence can naturally change what the standard should be so that the old standard of performance is no longer realistic in terms of the changes which have come about. However, with an adequate descriptive write-up, it is possible at any time in the future to check back to determine if changes affecting the standard have been made.

For example, there is on record a company which had developed standard data for core room operations. During the course of about ten years, average performance increased until it had reached 200 per cent of standard. Obviously, something had changed during those ten years, but proof of change could not be made because standard data did not contain a description of the methods, the materials or the equipment. It did not even contain a sketch of the layout of the department as it existed at the time the standard data were developed.

Had these things been included in the original descriptive write-up, the company would have had available substantiating proof of change and could have corrected their standards accordingly. They had gone on for years paying largely unearned wages which greatly and needlessly increased their costs.

More fortunate was the company on record which, when it found the performance of the squeezer molding crew unreasonably high, readily determined from the descriptive write-up that the work elements of "carry out mold" and "return to machine" were performed on a sand floor. Concrete floors had been installed, along with other improvements which were also readily detectable, which made the old performance data obsolete. It was a relatively simple matter to correct standards to take advantage of the savings that should have been affected by the improvements.

What is required in the descriptive write-up of a set of standard data? It should cover in minute detail these items:

1) Conditions under which application is to be made, such as individual or group incentive.
2) Tools and equipment used, including a list of machines and their serial numbers, sand formulas, grinding wheel make and identification numbers, surface speed of grinding wheels, horsepower of motors, a list of small tools used, etc.
3) Description of each work element, and the "break point" (point at which the element ends and the watch is read in making time studies).
4) A description of the general process, telling where raw materials are stored, how they are delivered, what is done with finished pieces, who takes them away, etc.
5) A sketch of the relative position of the department to other departments and to the plant as a whole.
6) A sketch showing the individual work stations within the department, giving all the appropriate dimensions.
7) A sketch of one work station (if they are all laid out alike) within the department, giving all appropriate dimensions.
8) A description of the development of the data, showing which elements have been combined in each of the standard data charts together with the standard time for each element.
9) Instructions on how to factor production standards, including sketches explaining classifications.
10) Examples of factor cards used for the operation.
11) Description of all allowances included in the standard data.
12) Description of what constitutes delays and how they are to be paid.

A descriptive write-up covering the above points, provided it is carefully and adequately written, can prevent many of the difficulties encountered over a period of time because of "creeping changes" in methods. In general, it must be kept in mind that the twin pitfalls of standard data development are on the one hand over-complication, and on the other hand, over-simplification. Data should not be complicated to the point where the cost of establishing a production standard is too high. However, if data remain too simple there is danger that earnings will not be consistent with actual effort.

Setting Up Cost Control

It must never be forgotten that all of the activity involved in developing standard data and incentives is ultimately aimed at the primary goal of lowering (wherever possible) and controlling labor costs. Just

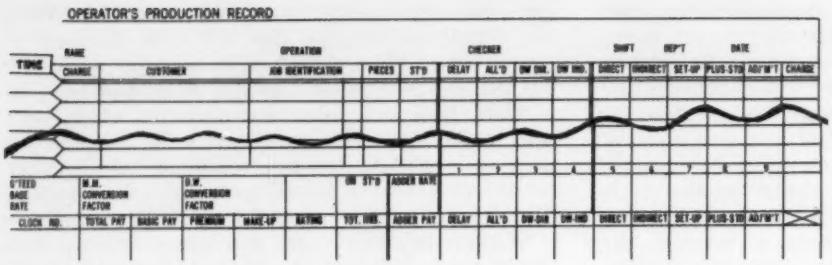


Fig. 2 — Daily production record form which is designed with cost control in mind as well as payroll.

as accurate measurement is the heart of accurate cost establishment, so effective reporting of conditions which affect costs is the heart of continuing cost control.

To be classed as effective, a reporting system must present conditions to management and supervision in a manner which not only accurately reflects conditions, but reflects them accurately before too much time has elapsed, before wasteful situations on tendencies have been allowed to go on long enough to do real harm. In addition, reports must be presented in a manner which is easily understandable and does not require too much time to analyze. If such a reporting system is not installed, no cost control system can be considered practical.

Reporting System

The effectiveness of a reporting system depends in large part upon the creation of paper forms for recording. Figure 2 shows a daily production record form which is designed with cost control in mind, as well as payroll. At first glance this form may appear complicated. However, it is actually easy to use, and is designed to segregate important key cost items. Thus, the first division is between standard and non-standard labor costs. This provides the basis for determining what portion of the payroll is on standard, and, therefore, controlled or controllable.

Further subdivisions go into direct, indirect and other categories for the purpose of determining what is production and what is waste on the payroll. Finally, all operators' daily production records for a given department or cost center are then summarized on a cost control summary (Fig. 3). This is primarily a work sheet designed for the purpose of collecting all labor costs for a given cost center and presenting them in a summarized form. The summary appears at the lower right hand corner of the sheet, where we find the pertinent labor cost information which supervision needs to control labor costs.

The pertinent items here include all waste items. These are (1) overtime premium, (2) make-up pay, (3) delay pay and (4) plus standard pay. Generally, the total of waste costs should not exceed 5 per cent of direct costs, and experience with a given cost center may establish an even lower norm. After that, at any time that the waste cost exceeds either 5 per cent or the established norm, supervision should immediately analyze the report to determine the major cause of waste, and then to bring costs back into line.

The summary sheet (Fig. 3) next lists the rating and the per cent of time on standard of the operators for the period covered by the report. The rating should consistently remain well over 100 per cent, and time on standard should never fall below 85 per cent. When either of those figures are violated, costs may soar to an alarming extent.

The next item listed in the cost control summary (Fig. 3) is the per cent of capacity at which the cost center concerned operated for the period reported. This item is not always controllable by supervision, but it does affect production costs through the distribution of overhead costs. In establishing a standard cost for the cost center, overhead costs are calculated so as to be absorbed at some pre-determined percentage of capacity. If and when actual production drops below this percentage of capacity, overhead costs are not fully absorbed and losses occur.

The next items on the control summary are direct cost/direct hour and total cost/direct hour. The direct cost is calculated by dividing the direct dollars by the direct (salable) hours produced, and reflects the average hourly base rate of all operators in that cost center. This could be considered an ideal cost/

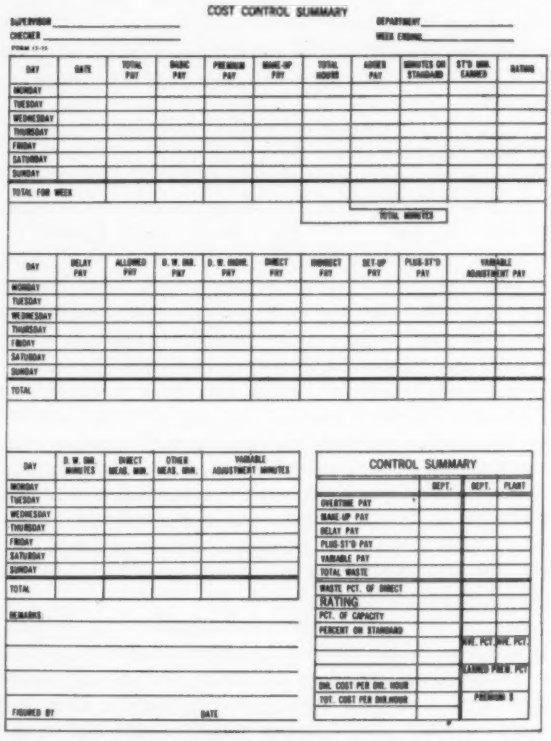


Fig. 3 — Cost control summary record. This is primarily a work sheet designed for the purpose of collecting all labor costs for a given cost center and presenting them in summarized form.

hour, since it is not possible for labor costs to be lower than the average base rate. Total cost/direct hour is found by dividing the total pay for the cost center by the direct salable hours produced. This figure reflects the final results of efforts to control labor costs.

Reporting with the view to controlling labor costs is most effective when quick comparisions can be made with the results of previous weeks. For this reason it is advisable to transfer the cost control figures we have explained above to a cost control record (Fig. 4), which shows progress for a full year. This affords a graphic record of the progress each supervisor is making toward controlling his labor costs.

Estimating and Pricing

At this point, having developed standard data for all direct operations and most of the indirect operations, and having instituted the necessary cost control report system, the next step is to develop a realistic estimating procedure.

The estimating form shown in Fig. 5 was designed for, and is used by, a small non-ferrous foundry. This form serves as a check list to remind the estimator of each item of cost which must be considered in calculating the selling price. Basic to its formulation is the use of standard cost conversion factors for each cost center in the plant. Without entering into detail of how this cost conversion is made, it should again be pointed out that it is based upon the standard data achieved through accurate measurement and analysis when establishing performance standards.

Production Control

Experience has proved that at this point of cost control development, all the pertinent information necessary to practical production control systems has been established and recorded. Developing an effective production control system, therefore, is not a matter of obtaining new or different data, but simply a procedure of consolidating and integrating data already available. Invariably this results in eliminating wasteful duplication of effort and record keeping, and at the same time bring essential data together in forms which are more convenient to handle and more accessible when required for use. The possibility of error is held to a minimum.

The chief purpose of a production control system may be divided into three practical, imperative goals. They are:

1) Establishing a promised delivery date on the basis of actual production conditions, rather than of wishful thinking.
2) Meeting that delivery date.
3) Reducing production costs.

Needless to say, delivery dates quite often are farcical in common practice due to lack of production control. It seems almost unbelievable that this condition should ever be allowed to exist, in view of the fact that to the average buyer of castings, service rates second only to quality while price rates third, behind service. Needless to say, the establishment and meeting of firm delivery dates can only result in greatly improved customer satisfaction with obvious bearing on sales volume.

In analyzing the information required for production control, it will be found that two categories of information are involved. These are:

1) Information necessary to produce the order.
2) Information relating to the progress of production.

The information necessary to produce the order must appear on shop orders. A considerable amount of clerical work which is usually required to produce a shop order can be saved, when it is considered that about 90 per cent of the information involved remains the same for any order received for a given pattern or part number. Essentially, the only information for a given pattern or part which varies from one order to the next consists of items such as order number, quantity on order, delivery dates required and promised.

Basic Order Forms

If modern duplicating equipment is used to produce an adequate supply of basic order forms for specific jobs to which they might apply, it only remains to add the specific information regarding quantities and deliveries to make the order complete. Figure 6 reproduces a permanent duplicating master order form which is re-issued every time a new order is received. The exact information appearing on it may be varied from foundry to foundry as required, but basically it will have the same information.

In ordinary practice, much of this information will be scattered in various offices or departments of the plant, with much of it never appearing on the shop order. The advantage of having it centralized on the shop order is that this practice eliminates not only the necessity of looking up information in other records, but actually eliminates the need for keeping other records at all.

For example, the order delivered to the pattern storage department is not only an order to send the pattern to the shop, but also instructions on where to locate the equipment, thus eliminating the need to search in pattern storage files for this information. Again, by returning the mold order with the pattern, the equipment can be stored properly without referring to any other records. In the same manner, shipping instructions on the order also eliminate the need for special record keeping in the shipping department, with consequent loss of time in keeping and checking needless records.

Information relating to the progress of production can also be simplified through centralization. Figure 7 reproduces a production control record card which is maintained in the office of the person responsible for the control of production. It provides, in one central location, the answers to all questions, either from the customer or management regarding the status of the order. This card, which is the heart of the production control system, can be designed for mechanical posting of data, but the smaller foundry will usually find that manual entry and calculation produces satisfactory results.

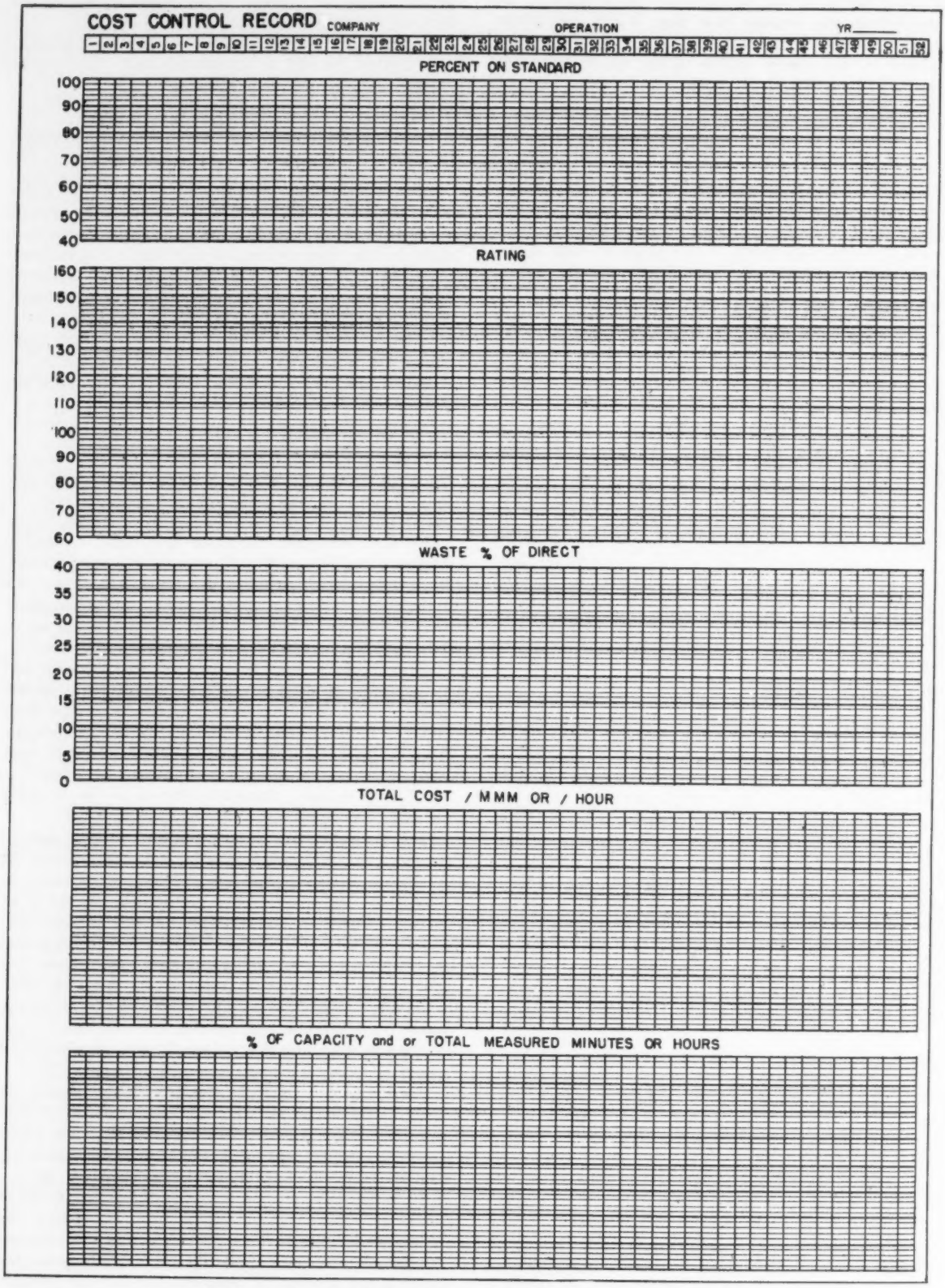


Fig. 4 — Cost control figures are transferred to the cost control record which shows progress for a full year. This affords a record of progress each supervisor is making toward controlling his department's labor costs.

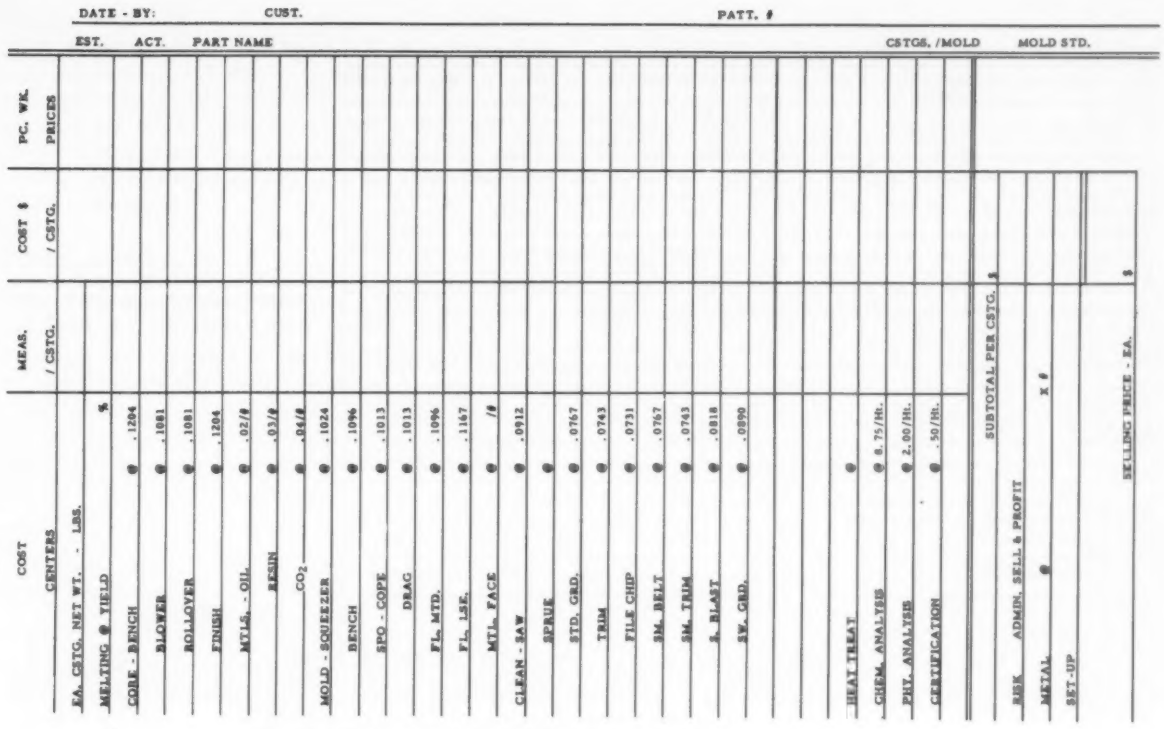


Fig. 5 — Estimating form designed and used by a small nonferrous foundry. This form serves as a check list to remind the estimator of each item of cost which must be considered in calculating selling price.

A system of colored flags attached to the production control record cards serves as a visual means of detecting any order still on file which is overdue. These colored flags, designating the month and week in which shipment is promised, also serve to establish that orders will be scheduled in the proper sequence.

Maintaining and Carrying Out the Cost Control System

The size of the plant, and to a certain extent the quantity of new and repeat orders received weekly, will determine the number of people required to maintain the cost control system which has now been developed. In the small foundry it is usually necessary for one person to double in more than one capacity, or even to assume responsibility for all of the various industrial engineering activities. However, regardless of the number of people involved, the various functions of the work remain the same for all practical purposes. It should be kept in mind that, at this point outside industrial engineering help is no longer utilized and that the work is carried on by plant personnel.

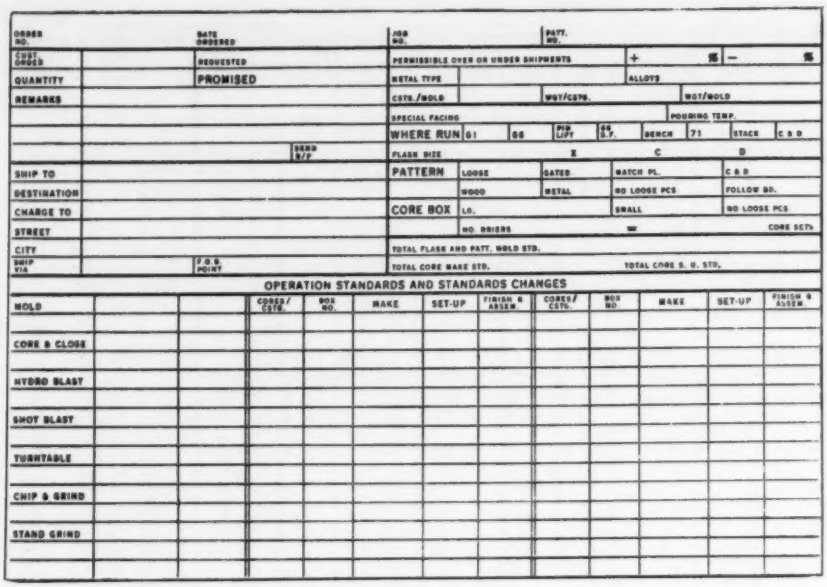
If the cost control system is not effectively maintained, all of the work of measurement, standard development and personnel training that has gone before will be wasted, since it is only when applied that the system will serve to control costs. Various factors are involved in maintaining the system effectively.

First, there is the maintenance of the incentive system. This must be done carefully and accurately, but it becomes almost a clerical function since the data on which it is based have already been developed. Foremen, particularly, must be alert to improvements in methods, so that they will be reported and considered in changing operation standards. Unless this is done the incentive system will fall far short of its purpose of lowering labor costs, since the savings which are supposed to come with the methods improvement will not be realized.

It is wise to make a periodical audit of the system to establish that standards are being kept up-to-date. The descriptive standard data write-up of methods in use in each department must be constantly scrutinized, and kept meticulously up to date, to avoid unrecorded creeping changes which can come over the years. If this is done, the incentive system will continue to serve its purpose of cost reduction, and savings, which are the result of methods improvements, will not be thrown away in the form of unearned wages.

In maintaining the estimating system, the actual job of estimating is best done by the standards man or standards department. The reason for this is that day-to-day use of standard data in setting up operation standards has provided the standards man with a knowledge of standard practices so necessary to accurate estimating. Also, the standards man should compare his estimates with actual operation standards which are set for incentive purposes after the order is received.

The maintenance of the production control system is essentially simple. Only if the type of production involved in the plant undergoes major changes, such as going from a short run job shop to long pro-



ORDER NO. | DATE ORDERED | JOB NO. | PATT. NO.

CUST ORDER | REQUESTED | PERMISSIBLE OVER OR UNDER SHIPMENTS + % – %

QUANTITY | PROMISED | METAL TYPE | ALLOYS

REMARKS | CSTS./MOLD | WGT/CSTG. | WGT/MOLD

SPECIAL FACING | POURING TEMP.

WHERE RUN G1 | G8 | PIT LIFT | FLOOR S.F. | BENCH | F1 | STACK | C & D

SEND R/F | FLASK SIZE X C D

SHIP TO | PATTERN LOOSE | GATED | MATCH PL. | C & D

DESTINATION | WOOD | METAL | NO LOOSE PCS | FOLLOW BD.

CHARGE TO | CORE BOX LG. | SMALL | NO LOOSE PCS.

STREET | NO. DRIERS | SK | CORE SETS

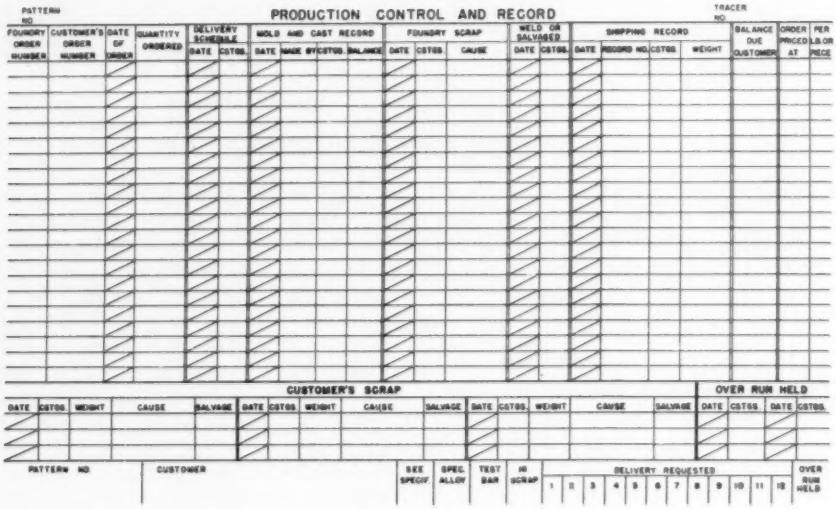
CITY | TOTAL FLASK AND PATT. MOLD STD.

SHIP VIA | F.O.B. POINT | TOTAL CORE MAKE STD. | TOTAL CORE S. U. STD.

OPERATION STANDARDS AND STANDARDS CHANGES

MOLD	CORES/ CSTG.	BOX NO.	MAKE	SET-UP	FINISH & ASSEM.	CORES/ CSTG.	BOX NO.	MAKE	SET-UP	FINISH & ASSEM.
CORE & CLOSE										
HYDRO BLAST										
SHOT BLAST										
TUMBLE										
CHIP & GRIND										
STAND GRIND										

Fig. 6 — A permanent duplicating master order form re-issued every time a new order is received.



PATTERN NO. | PRODUCTION CONTROL AND RECORD | TRACER NO.

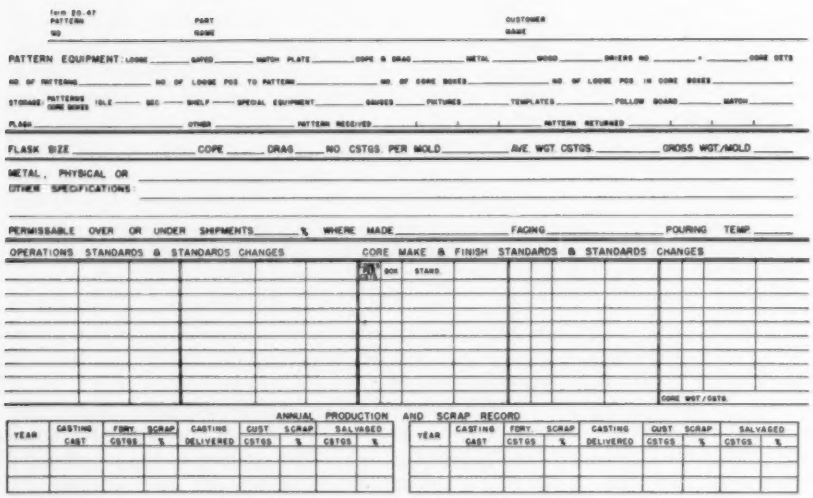
FOUNDRY ORDER NUMBER	CUSTOMER'S ORDER NUMBER	DATE OF ORDER	QUANTITY ORDERED	DELIVERY SCHEDULE DATE	DELIVERY SCHEDULE CSTGS.	MOLD AND CAST RECORD DATE	MAKE BY	CSTGS.	BALANCE	FOUNDRY SCRAP DATE	CSTGS.	CAUSE	WELD OR SALVAGED DATE	CSTGS.	SHIPPING RECORD DATE	RECORD NO.	CSTGS.	WEIGHT	BALANCE DUE CUSTOMER	ORDER PRICED AT	PER LB OR PIECE

CUSTOMER'S SCRAP | OVER RUN HELD

DATE	CSTGS.	WEIGHT	CAUSE	SALVAGE	DATE	CSTGS.	WEIGHT	CAUSE	SALVAGE	DATE	CSTGS.	WEIGHT	CAUSE	SALVAGE	DATE	CSTGS.	DATE	CSTGS.

PATTERN NO. | CUSTOMER | SEE SPECIF. | SPEC. ALLOY | TEST BAR | IN SCRAP | DELIVERY REQUESTED 1 2 3 4 5 6 7 8 9 10 11 12 | OVER RUN HELD

Fig. 7a — One side of a production control card which is maintained in the office of the person responsible for the control of production.



form 20-47 | PATTERN NO. | PART NAME | CUSTOMER NAME

PATTERN EQUIPMENT: LOOSE ____ GATED ____ MATCH PLATE ____ COPE & DRAG ____ METAL ____ WOOD ____ DRIERS NO. ____ • ____ CORE SETS

NO. OF PATTERNS ____ NO. OF LOOSE PCS. TO PATTERN ____ NO. OF CORE BOXES ____ NO. OF LOOSE PCS. IN CORE BOXES ____

STORAGE: PATTERNS ____ CORE BOXES ____ IDLE ____ SEC. ____ SHELF ____ SPECIAL EQUIPMENT ____ GAUGES ____ FIXTURES ____ TEMPLATES ____ FOLLOW BOARD ____ MATCH ____

FLASH ____ OTHER ____ PATTERN RECEIVED ____ / ____ / ____ PATTERN RETURNED ____ / ____ / ____

FLASK SIZE ____ COPE ____ DRAG ____ NO. CSTGS. PER MOLD ____ AVE. WGT. CSTGS. ____ GROSS WGT./MOLD ____

METAL, PHYSICAL OR OTHER SPECIFICATIONS: ____

PERMISSABLE OVER OR UNDER SHIPMENTS ____ % WHERE MADE ____ FACING ____ POURING TEMP. ____

OPERATIONS STANDARDS & STANDARDS CHANGES | CORE MAKE & FINISH STANDARDS & STANDARDS CHANGES

MOLD	CORES/ CSTG.	BOX NO.	STAND.	CORE WGT./CSTG.

ANNUAL PRODUCTION AND SCRAP RECORD

YEAR	CASTING CAST	FORY CSTGS	FORY %	SCRAP CASTING DELIVERED	CUST CSTGS	CUST SCRAP %	SALVAGED CSTGS	SALVAGED %

YEAR	CASTING CAST	FORY CSTGS	FORY %	SCRAP CASTING DELIVERED	CUST CSTGS	CUST SCRAP %	SALVAGED CSTGS	SALVAGED %

Fig. 7b — Reverse side of card shown in Fig. 7a.

duction runs, will the production control system require revisions. Since most small foundries are job shop operations, the daily operation of the system will not vary greatly. Once set up, with a scheme whereby all information pertaining to delivery and production is simplified and centralized, this phase of the cost control system is more likely than any other to run itself.

CONCLUSIONS

Since the small foundry exists in a highly competitive field, it is obvious that its need for effective cost control is just as great as that of the large foundry with hundreds of employees.

For practical purposes the basic problems of industrial engineering remain the same, whether applied to large or to small companies. The difference lies initially in the fact that the small foundry is not equipped with an experienced industrial engineering department. This makes it advisable to bring in outside help on a consulting basis for the purpose of ascertaining facts and actual conditions, of devising a specific cost control plan, of training selected foundry personnel and of formulating basic standard data.

Thereafter, maintenance of the system which has been developed is carried on by trained foundry personnel. Such a cost control system, if maintained scrupulously, will not wear out with the passage of a few years and the coming of changed conditions. It will adapt itself and constantly keep pace to new methods and situations, with the result that costs will remain under control, improved methods or equipment will result in actual savings, and pricing will continually remain highly competitive on the most realistic basis possible.

HOW TO AVOID SAND SEGREGATION

Based on work done jointly by Committee 8-F of the AFS Sand Div. and the Grading & Fineness Committee of the National Industrial Sand Assoc.

ABSTRACT

The problem of sand segregation was studied, with particular reference to the loading and unloading. Sands colored to indicate fineness were used in the tests. Recommendations based on the results of these tests are given.

INTRODUCTION

Segregation of foundry sands is not a new problem with foundrymen. It has been a constant problem in foundries and with sand producers. However, the problem has become more evident because of vast improvements in sand technology and a greater emphasis on sand control. This added emphasis on sand technology and quality control of castings had led to a greater realization of the importance of sand distribution and grading in foundry operations. Sand segregation problems become more important, since variation in grain distribution ultimately leads to variation in casting quality.

The Joint Committee undertook the study of sand segregation to learn where segregation asserts itself to the greatest extent, and to investigate possible means of reducing it to a minimum.

Sand segregates every time it is moved from one place to another regardless of the method of transportation—truck, rail, wheelbarrow, screw conveyor, belt conveyor, bucket elevators or any other known method. Segregation is most extensive when sand is placed in storage or removed from storage, both at the point of production and at the point of consumption.

One of the participating companies gathered experimental data to demonstrate segregation and indicate one possible method for its control. The work involved the study of a dry sand being loaded and unloaded from a storage silo. The sieve analysis of the sand is shown in the basic test column Table 1.

For the purposes of visually demonstrating segregation the base sand was divided into three fractions: that which was retained on a U.S. Series Sieve No. 40 and coarser was dyed red; from 50 to 100, no dye; and 140 and finer, dyed blue. The three sand fractions were thoroughly mixed and loaded into the experimental square silo made of plate glass with a plexiglass bottom (Fig. 1).

Four experiments were run, with the sand being loaded as indicated in Fig. 2 and subsequently withdrawn. The *X* indicates the point at which the sand was loaded into the top of the silo, and the *O* indicates the discharge point on the bottom.

TEST PROCEDURE

In the first experiment the sand was introduced at the center of the top of the silo through a 1-in. diameter opening. The sand was discharged from the bottom of the tin through sixteen ⅜-in. diameter openings. In each of the other three experiments, the sand was introduced through 1-in. diameter inlets and discharged through 1-in. diameter outlets, as shown in 2, 3 and 4 of Fig. 2.

Colored motion pictures were taken while the silo was being emptied. The dyed sand clearly showed the segregation which takes place when dry sand is handled in each of the four ways. Segregation of sand particles always occurs in the same manner. The coarsest particles always roll to the outside and the finer particles remain in the center Fig. 3.

A complete sieve analysis for tests 1 and 4 is shown in Tables 1 and 2. The numbers at the heads of the columns locate the point at which the top level of the sand was located at the time each sample was taken. The white marks on right-hand silo brace in Fig. 1 are numbered from zero to nine, starting at the top, graduated 6-in. apart.

In the four tests run, the same well-mixed sand sample with an AFS Grain fineness number of 69.71 was used. In test 1, the AFS Grain fineness number

---

Members of the AFS Grading, Fineness and Distribution Committee (8-F) who conducted this work are, *Chairman* T. W. Seaton, American Silica Sand Co., Inc., Ottawa, Ill.; *Vice-Chairman* J. G. Smillie, John Deere & Co., Materials Engineering Dept., Moline, Ill.; R. W. Bennett, Walter Gerlinger, Inc., Milwaukee; W. D. Chadwick, Manley Sand Co., Rockton, Ill.; L. F. Dennie, Technical Service, Detroit; George DiSylvestro, American Colloid Co., Skokie, Ill.; H. E. Donnocker, Ottawa Silica Co., Ottawa, Ill.; E. M. Durstine, Keener Sand and Clay Co., Columbus, Ohio; H. S. Fagan, The Fahralloy Co., Harvey, Ill.; F. P. Goettman, Standard Sand Co., Grand Haven, Mich.; L. D. Marinelli, Kensington Steel Co., Chicago; R. E. Morey, Metallurgy Div., Naval Research Laboratory, Washington, D. C.; George Nestor, National Malleable & Steel Castings Co., Cleveland; J. S. Schumacher, The Hill & Griffith Co., Cincinnati; J. A. Schumann, Carpenter Bros., Inc., Milwaukee; E. W. Smith, Foundry Materials, Chicago; N. J. Stickney, Sand Products Corp., Cleveland; T. A. Tarquinio, American Manganese Steel Div., Chicago; L. E. Taylor, Ottawa Silica Co., Ottawa, Ill.; Stanton Walker, National Industrial Sand Association, Washington, D.C.; S. A. Wick, New Jersey Silica Sand Co., Milville, N. J.

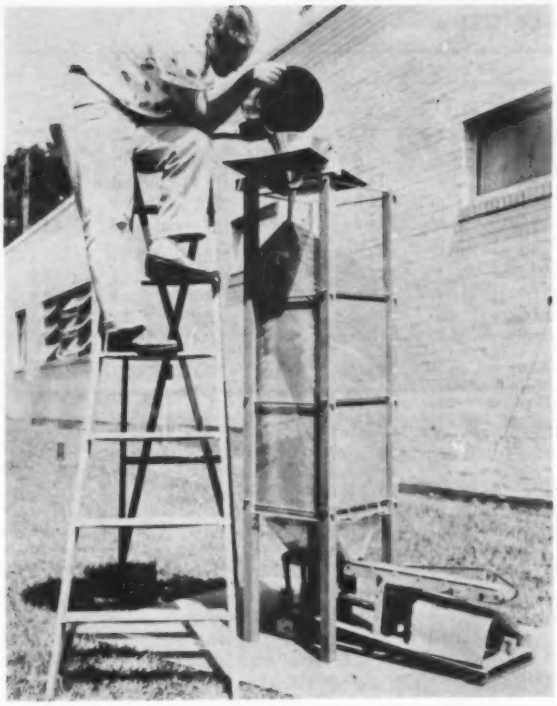


Fig. 1 — Dry sand loading and unloading was studied in an experimental square silo made of glass. The white marks on the right-hand silo brace are numbered from zero to nine starting at the top and 6-in. apart.

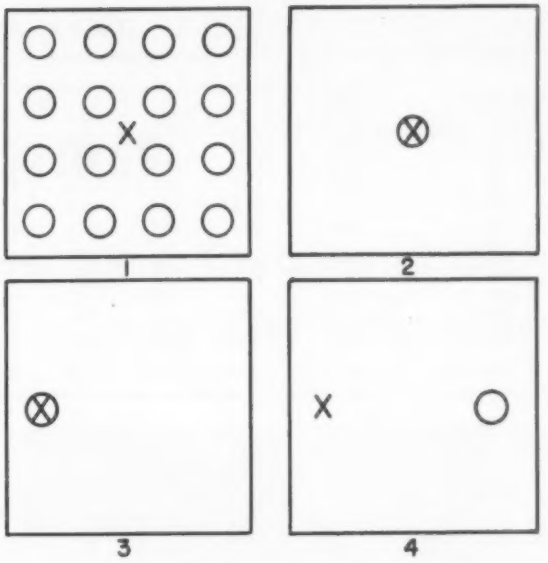


Fig. 2 — Four experiments were conducted with sand being loaded as indicated. The *X* indicates the point at which the sand was loaded into the top of the silo, and the 0 indicates the discharge point on the bottom of the silo.

of samples drawn from the storage bin varied from a low of 66.19 to a high of 72.32. In test 2 this spread ranged from 61.74 to 75.61. Test 3 showed a spread from 61.38 to 84.91, and test 4 varied from 51.98 to 81.65. The marked superiority of the first technique is evident.

These experiments demonstrated that the practice of using several or a large number of openings when withdrawing sand from storage is one of the best developed so far to minimize segregation. This practice should be encouraged as much as possible throughout the industry. The variation in sieve tests taken at various stages of unloading the test silo clearly indicate that segregation had been kept to a minimum.

It is safe to assume that these variations will occur in the sand when withdrawn from large storage areas. These measurements show that sand castings would be made under varied conditions in spite of the fact that the base analysis of the sand is satisfactory. Casting finish and other variables will vary rather substantially.

Sand producers and foundrymen should make every possible effort to draw sand from storage using as many openings at the base of their bins or silos as possible. These openings should be distributed uniformly over the complete base of the silo or bin. In addition, the orifice-type discharge is being used successfully, and should also be considered.

RECOMMENDATIONS

The following recommendations are offered to producers and consumers as methods of further minimizing segregation.

Unloading

Wheelbarrows, endloaders and grab buckets. When unloading sand from cars, work across the car perpendicular to the track in order to get as complete a cross-section of the sand in the car as possible. This

TABLE 1 — RESULTS OF TEST 1

U. S. Sieve No.	Basic Test	Retained, %								
		1	2	3	4	5	6	7	8	9
20	1.0	0.7	1.0	0.9	1.2	0.9	1.0	1.0	1.0	1.0
30	11.4	11.4	10.7	10.7	12.3	11.5	12.5	12.6	10.3	10.3
40	14.3	15.2	13.9	13.7	15.6	14.4	15.9	15.1	12.1	12.5
50	11.4	11.3	11.1	10.5	11.0	10.0	10.6	10.0	13.2	15.3
70	14.9	14.8	14.5	15.1	15.0	14.3	13.8	13.9	15.2	17.4
100	14.9	14.9	15.4	15.9	15.8	14.2	13.6	13.0	15.6	15.7
140	18.5	17.7	19.0	19.0	17.7	19.4	18.9	18.9	19.0	17.0
200	9.5	9.6	10.3	9.7	8.5	10.3	10.1	10.5	9.7	7.4
270	3.5	3.8	3.4	3.9	2.4	4.3	3.1	4.3	3.3	2.9
Pan	0.6	0.6	0.7	0.6	0.5	0.7	0.5	0.7	0.6	0.5
AFS GFN	69.71	69.80	71.60	70.40	66.19	72.32	68.77	72.00	70.57	66.38

TABLE 2 — RESULTS OF TEST 4

U. S. Sieve No.	Basic Test	Retained, %										
		0	¼	½	1	2	3	4	5	6	7	8
20	1.0	1.6	1.6	1.7	1.6	0.5	0.7	1.1	1.0	1.1	0.7	1.7
30	11.4	17.1	15.2	15.5	15.7	7.0	8.6	12.5	12.2	13.6	9.7	18.3
40	14.3	19.4	18.7	17.4	17.5	9.4	11.6	14.5	15.4	15.9	14.4	18.7
50	11.4	14.5	15.0	13.8	13.3	10.2	11.4	11.5	12.6	11.7	12.8	11.9
70	14.9	17.7	16.8	17.7	14.9	15.0	14.5	14.8	14.8	14.4	15.9	13.8
100	14.9	13.5	14.2	14.6	14.3	16.4	15.9	14.0	13.7	13.7	15.1	11.8
140	18.5	11.8	13.7	13.9	15.3	22.3	20.8	17.5	17.5	17.3	18.4	13.9
200	9.5	3.7	4.2	4.7	6.1	12.3	11.7	9.3	9.1	8.7	9.6	7.0
270	3.5	0.6	0.6	0.7	1.2	5.9	4.0	4.1	3.1	3.2	2.9	2.6
Pan	0.6	0.1	T	T	0.1	1.0	0.8	0.7	0.6	0.4	0.5	0.3
AFS GFN	69.71	51.98	53.93	54.96	57.87	81.65	75.79	69.58	67.43	66.15	69.11	59.16

Fig. 3 — Segregation of sand particles always occurs in the same manner. The coarsest particles always roll to the outside, and the finer particles remain in the center.

will assist in reblending the sand and counteract segregation as it is placed into storage.

Bottom dump equipment. Segregation is nearly impossible to control at the point of discharge, and reblending must be accomplished from this point on to storage.

Conveying and Storing

Belts. Distance of fall onto and from the belt should be as short as possible. Wider belts running at slower speeds are better than narrow belts at high speeds for reducing peaking of sand on the belt. The use of baffles and cones at the point of discharge helps distribute sand uniformly throughout the storage area.

Bucket elevators. The use of baffles at the discharge point is important.

Pneumatic conveying. Information on this method is too limited at this time to make any recommendations.

Gravity flow. Baffles should be used to retard the speed of sand flow and minimize the distance of free fall.

Screw Conveyors. Segregation is kept to a minimum with this method of conveying.

Storing. When discharging into storage, endeavor to distribute sand uniformly throughout the storage area.

CONCLUSIONS

The following conclusions were drawn as a result of this study:

1) Sands of high clay content will segregate less than those which are nearly or entirely clay free.
2) Dry sands show a much greater tendency toward segregation than damp sands.
3) Sands of wide grain-size distribution will segregate more than those of narrow distribution. This in no way condemns the use of broadly distributed sands, but rather is intended to point out where segregation occurs to the greatest extent.
4) Sand tends to segregate every time it is handled.

This study has shown the segregation effect of sand on its distribution, and has indicated the sensitivity of dry, low clay containing sands to segregation. The importance of controlling segregation cannot be overemphasized whether it be at the point of production or the point of consumption.

Recommendations have been made by this committee for methods of keeping segregation to a minimum, and it is hoped that these recommendations will be useful to foundrymen and sand producers everywhere.

HIGH STRENGTH STEEL CASTINGS

mechanical properties and processing techniques

By K. D. Holmes, J. Zotos and P. J. Ahearn

ABSTRACT

Mechanical property evaluation was made on high strength test coupons and castings manufactured under various melting and heat treating conditions. Properties of arc furnace and induction melted material were compared, and the effectiveness of certain heat treatments were assessed. Best combination of strength, ductility and toughness was obtained in thin sections of low sulfur and phosphorus steel cast from arc furnace heats.

INTRODUCTION

In recent years the desire for lightweight equipment has sparked considerable interest in the development of high strength cast steels having ductility and toughness comparable to Ordnance steels now employed at lower strength levels. At the present time cast steels in the 150,000 psi yield strength range are quite practical especially in thin sections, while higher strengths than that quoted should be considered as developmental. Every effort is being made to increase the practical yield strength level to the 200,000 psi range, while still maintaining ductility and toughness in the final product.

It is recognized that the inherent cleanliness and chemical composition of steel as poured from the ladle has a considerable effect on the subsequent performance of that steel during mechanical testing. Accordingly, great emphasis has been placed on the development of arc furnace and induction melting practices that produce clean steels of the requisite chemical analysis.

In addition, heat treatment variables have been studied to maximize the formation of low temperature transformation products during the hardening treatment. A third area of investigation, the solidification of high strength steels, is being conducted under contract with a private institution. Results[1] of this work are being incorporated into current Watertown Arsenal practice for manufacturing high strength steel castings.

This paper outlines the current high strength steel manufacturing procedure, and presents a philosophy of manufacture consonant with the attainment of high strength and ductility in the finished product. The mechanical property results submitted for examination are in the strength range between 140,000 and 270,000 tensile strength, and are representative of various size test blocks and actual development castings.

K. D. HOLMES, J. ZOTOS and P. J. AHEARN are Met., Rodman Laboratory, Watertown Arsenal, Watertown, Mass.

PROCEDURE

Refractories and Raw Materials

In the melting and casting of high strength steels the constituents of the furnace charge and the refractories employed in and around the furnace must be selected with considerable care, for many potential problems can be eliminated at the very start by proper selection. The furnace, ladle and pouring pit refractories are magnesia brick or magnesia ramming mix. Magnesia possesses a desirable combination of refractory properties such as high melting point, chemical inertness to basic slags and good spalling and erosion resistance which minimizes the presence of mechanically entrapped inclusions in the steel.

The constituents of the furnace charge are somewhat dependent upon the type of melting equipment employed. Induction furnace charges consist of a low carbon steel bar stock with a specified, maximum sulfur and phosphorus of 0.025 per cent, but in general the percentage is in the 0.015 – 0.020 per cent range. The pig iron for the carbon addition and the alloys are also purchased in accordance with this maximum tramp element requirement. The charge for an arc furnace heat is always first quality heavy scrap. The same alloys as those employed in the induction furnaces are used along with slag making materials such as limestone, fluorspar and iron oxide.

All inputs are dry and relatively free of rust, scale and oil. This same precaution is also taken with melters tools, such a skimmers and rabbles, that come in contact with the bath. Great emphasis is placed on the necessity for clean, moisture free inputs which minimize absorption of hydrogen by the steel. Thus, the mechanical properties of the castings produced are not degraded by the presence of hydrogen.[2]

Melting Practice

The induction practice is primarily a remelting and alloying operation; extensive refining of the steel is impractical. The bar stock is melted with the inert alloys molybdenum and nickel. Pig iron and ferrochromium are then added, and a mild carbon boil is obtained which tends to flush out any hydrogen absorbed during the meltdown. The bath is deoxidized with ferromanganese and ferrosilican additions, superheated and tapped; final deoxidation with aluminum is conducted in the metal stream.

On the other hand, the arc furnace practice is designed to take advantage of every practical means known to reduce the sulfur and phosporus content to extremely low levels, and to produce a steel low in gas content and free of nonmetallic inclusions. This is accomplished using a double slag basic practice[3] similar to that employed in the production of steels for forging. The highly basic oxidizing slag employed during the boil period reduces the phosphorus and hydrogen contents to low levels. This slag is removed, and deoxidation of the bath is achieved by the addition of carbon, ferromanganese and ferrosilicon.

The reducing slag is then developed to eliminate sulfur, and to maintain static conditions in the bath that allow accurate chemical control so that final analysis will be to specifications. Final deoxidation is conducted with aluminum in the ladle, and pouring temperature is accurately controlled through the use of high temperature thermocouples.

Pouring Practice

The metal is teemed from a bottom-pour ladle into suitable skin-dried green sand molds that have been gated and risered for complete soundness. Figure 1 shows the pattern, rigging and drum cradle casting. The molding mix is an 80 AFS sand mulled with 4¼ per cent Western bentonite, 3.5-4 per cent water and 1 per cent cereal. Suitable insulation, usually rice hulls, is placed on the riser surface, and the castings are allowed to cool in the molds to at least 600 F before shakeout.

Heat Treatment

The heat treatment is designed to maximize the development of low temperature transformation products in the steel. This is accomplished through a high temperature homogenize and normalize, followed by an austenitize, quench and double temper to the desired strength level. Certain precautions are taken to insure that the above objective is met. For example:

1) High temperature scale formed during the homogenize and normalize is removed by shot blasting prior to the quench, for this scale could reduce quench severity.
2) Carbon content of the steel is as low as possible in order to reduce susceptibility to quench cracking, and also to obtain optimum combination of strength and ductility.[4]
3) The austentizing temperature is within the standard temperature range for the subject steel, but before quenching the furnace temperature is reduced to a point approximately 50 F above the Ar_3 transition temperature.[5] This procedure reduces the amount of heat that is ordinarily removed during the quench, and thus the effective quench severity is increased without causing drastic thermal gradients that lead to quench cracks in the casting.
4) The quenching medium is usually water. When necessary, an interrupted quenching procedure, first in water and then in oil, is employed in preference to a straight oil quench.
5) Hardenability of the steel is more than adequate for the section size being treated. Retained austenite, usually associated with excess hardenability, is eliminated through the double temper treatment.
6) The tempering temperature is selected to avoid any embrittlement range, and the steel is often quenched from the temper for the same reason.

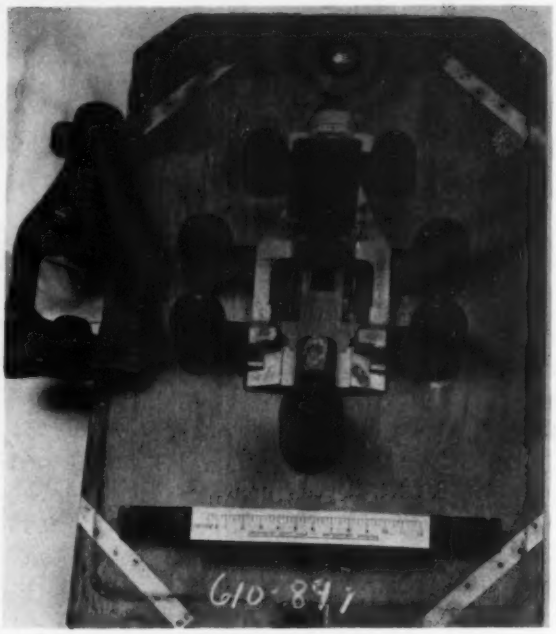


Fig. 1 — Pattern, rigging and drum cradle casting.

It is realized that the benefit derived through some of these precautions may be marginal, but because of the developmental nature of the program such marginal improvements are justified in view of the desire for maximization of mechanical properties.

Testing

A sketch of the coupon block for mechanical testing is shown in Fig. 2. Design of coupon allows the researcher to test in thin sections (fins), and also at the midwall and center of a massive section. Thus, he can study mass or section size effect in relation to mechanical properties. Results of coupon testing is always confirmed by tests conducted on actual shape castings whenever such is involved.

The mechanical property evaluation is made on 0.357 in. diameter threaded tensile bars and 0.394 in. square V-notch Charpy bars that have been removed from suitable casting locations.

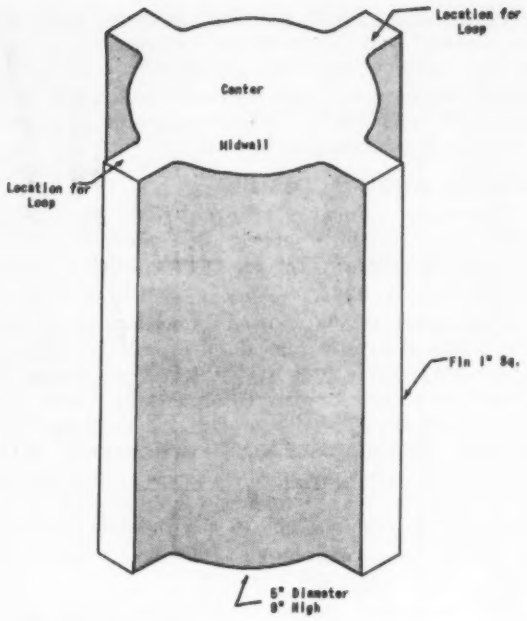


Fig. 2 — Sketch of coupon block.

The steels generally employed do not have a well defined ductile to brittle transition over a narrow temperature band, rather it is spread out over a considerable temperature range. The lower part of the transition occurs at between −20 and −40 F. At these testing temperatures, fibrosity of the Charpy fracture should be between 10-15 per cent. In the preparation of these test bars final grinding to finish dimensions is carefully controlled, for high strength steels will develop grinding cracks. This danger is easily eliminated by maintaining adequate coolant flow during this operation.

Mechanical test information is often supplemented by metallographic inspection for structure and nonmetallic inclusions, and macroexamination for overall quality, cleanliness and soundness. Such additional information can be most valuable in predicting steel performance prior to mechanical testing, or can be used to ascertain reasons for premature failure of specific test bars.

Steel Chemistry

The data presented herein are confined to two basic analyses, the first one being a chromium, nickel, molybdenum steel that has been used extensively in the manufacture of heavy-walled tubes and massive castings. The basic analysis of this steel was modified slightly with respect to carbon for the high strength program. The second analysis, a S.A.E. 4340 modified with 1.5 per cent silicon, was selected for its ability to resist temper embrittlement. The exact chemistries for each heat of the program appear in Table 1.

TABLE 1 — HIGH STRENGTH STEEL COMPOSITIONS

Cr-Ni-Mo Steels	Compositions, % C	Mn	Si	S	P	Ni	Cr	Mo	Al	V
Arc Furnace										
Arc - 1	0.305	0.83	0.30	0.009	0.009	2.35	0.76	0.84	0.045	
Arc - 2	0.245	0.87	0.42	0.008	0.009	2.48	0.74	0.44	0.055	
Arc - 3	0.295	0.82	0.52	0.009	0.009	2.48	0.76	0.42	0.050	
Induction Furnace										
Ind - 1	0.38	0.66	0.30	0.027	0.013	2.31	0.87	0.43	0.041	0.15
Ind - 2	0.33	0.64	0.34	—	—	2.12	0.89	0.43	—	0.125
Silicon Modified Induction Furnace										
Ind - 3	0.37	1.46	1.64	0.022	0.017	1.30	—	0.31	0.020	

These two analyses were employed in the manufacture of finned coupons from both arc furnace and induction melts. In addition, the chromium, nickel, molybdenum analysis was used for the production of high strength drum cradle castings.

The specific processing procedure for each type of casting is given in the schedules appearing as Tables 2 and 3. Table 2 presents necessary processing information pertinent to finned coupons cast from the chromium, nickel, molybdenum arc furnace steel, while Table 3 gives the same information for induction steels of the chromium, nickel, molybdenum and silicon modified analysis cast into finned molds as well as procedure for the cradle castings.

Comparison of these tables will point out certain planned differences in practice designed to allow the investigator an opportunity for correlation of these variations with resulting mechanical properties. For example, steels (Table 2) were manufactured in the arc furnace, and then cast and heat treated in such a way as to eliminate any tendency for quench cracking by employing a slack quench. It is believed the major variation is represented by the interrupted quench and the double slag basic melting and refining practice. As has been mentioned, this practice yields clean steel unusually low in sulfur and phosphorus content.

On the other hand, induction melted steels (Table

TABLE 2 — PROCESSING SEQUENCE FOR ARC FURNACE Cr-Ni-Mo CASTINGS

Heat No.	Casting Type	Treatment Schedule
		Low Strength Treatment *Normalize:* 1900 F, 16 hr; air cool (remove gates and risers, shot blast, weld quenching loops). *Harden:* 1650 F, 6 hr; furnace cool to 1500 F, 2 hr; H_2O quench, 5½ min; air, 10 min; oil, 15 min. *Temper:* 600 F, 2 hr; raise to 1130 F, 6 hr; oil quench, 15 min. *Soak:* 600 F, 12 hr.
Cr-Ni-Mo Steels Arc - 1 Arc - 2 Arc - 3	Finned Coupons	**or High Strength Treatment** *Homogenize:* 2200 F, 5 hr; air cool. *Normalize:* 1750 F, 3 hr; air cool. *Anneal:* 1225 F, 4 hr; furnace cool (remove gates and risers, shot blast, weld quenching loops). *Harden:* 1600 F, 3 hr; furnace cool to 1350 F, 2 hr; H_2O quench, 1½ min; air, 5 min; oil, 1 min. *Double Temper:* 400 F, 6 hr; air cool.

TABLE 3 — PROCESSING SEQUENCE FOR INDUCTION FURNACE HIGH STRENGTH CASTINGS

Heat No.	Casting Type	Treatment Schedule
Cr-Ni-Mo Steels		
Ind - 1	Finned Coupons	*Homogenize:* 2200 F, 8 hr; air cool. *Normalize:* 1750 F, 8 hr; air cool. *Anneal:* 1225 F, 12 hr; furnace cool (remove gates and risers, shot blast, weld quenching loops). *Harden:* 1600 F, 4 hr; furnace cool to 1325 F, 2 hr; H_2O quench cold. or *Double Temper* at 300 F, 16 hr; H_2O quench from temper.
Ind - 2	Drum Cradles	*Homogenize:* 2200 F, 5 hr; air cool. *Normalize:* 1750 F, 3 hr; air cool. *Anneal:* 1225 F, 4 hr; furnace cool (remove gates and risers — shot blast). *Harden:* 1600 F, 3 hr; furnace cool to 1500 F, 2 hr; oil quench. *Double Temper:* 775 F, 4 hr; water quench. or *Double Temper:* 825 F, 4 hr; water quench. or *Double Temper:* 1175 F, 4 hr; water quench. or *Double Temper:* 1200 F, 4 hr; water quench.
Silicon Modified Steel		
Ind - 3	Finned Coupons	*Homogenize:* 2200 F, 8 hr; air cool. *Normalize:* 1750 F, 8 hr; air cool. *Anneal:* 1225 F, 12 hr, furnace cool (remove gates and risers, shot blast, weld quenching loops). *Harden:* 1600 F, 4 hr; furnace cool to 1325 F, 2 hr; H_2O quench. *Double Temper:* 600 F, 16 hr; H_2O quench from temper. or *Double Temper* at 300 F, 16 hr; H_2O quench from temper.

3) were cast and heat treated to optimize the development of maximum properties through the heat treatment cycle. Coupons were water quenched cold so that massive sections would have the opportunity to exhibit properties comparable to fins. The cradle castings were processed in exactly the same way as the coupons, except that an oil quench was required in view of the complex casting geometry and the thin sections involved.

In all cases tempering temperatures were adjusted somewhat in conformance with objectives. Arc furnace coupons were tempered to tensile strength levels of 135,000 and 225,000 psi. Direct comparison could be made of deterioration in ductility, etc., with increased strength. In addition, high strength coupons from the arc furnace practice could be compared with similar coupons (Table 3) from the induction practice. Tempering temperature for the silicon modified steel was as low as possible in order to obtain maximum strength, while tempering treatments for the cradles were varied to obtain properties over a range of strength levels.

Tensile and Charpy bars were removed from the fin, midwall and center of the coupons, while tests on the cradle castings were conducted by sectioning and removing bars from highly stressed areas (Fig. 3). These tests disclose exact mechanical properties of cradles that were not sectioned.

RESULTS AND DISCUSSIONS

Mechanical properties resulting from the various processing procedures appear in Tables 4 - 8. Table 4 is an outgrowth of procedural Table 2, while Tables 5 - 8 are complementary to procedural Table 3.

Steels from the arc furnace (mechanical properties, Table 4) exhibit high ductility in thin sections. At the 135,000 psi strength level little deterioration in properties is noted when tests are taken from the thicker sections. This is not the case with the high strength 225,000 psi tensile strength results. Here, there is a marked difference in properties between the fin and midwall and, in addition, the yield-tensile strengths ratio is reduced. Such a trend is generally attributed to microstructural constituents associated with a slack quench.[6]

We can surmise that a drastic water quench from the austenitizing temperature would have improved midwall properties. The desirable high strength fin properties are reproducible for the results are from three different arc furnace heats, and each result presented represents the average of four tests. It is inferred that thin-walled castings would have proper-

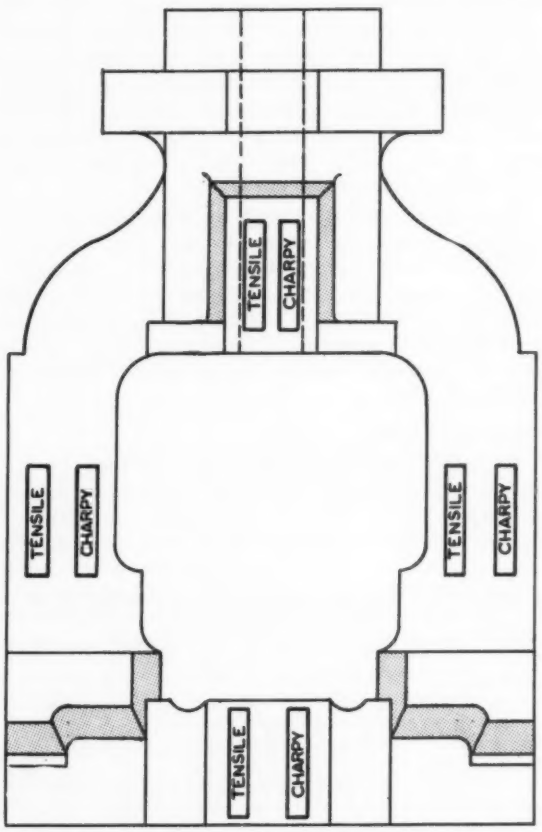


Fig. 3 — Test locations for drum cradle.

TABLE 4 — MECHANICAL PROPERTIES OF Cr-Ni-Mo ARC FURNACE STEELS

Heat No.	Y.S.—0.1%, psi	Y.S.—0.2%, psi	T.S., psi	0.1% Y.S. T.S.	Elong., %	R. A., %	Impact at —20 F, ft-lb	Fibrosity, %
Coupons Heat Treated to 130,000 T.S. Tempered at 1130 F.								
Arc-1-Fin	124,625		139,750	0.89	17.3	44.2	44.0	100
Arc-1-Mid	122,000	123,875	142,500	0.87	13.6	28.2	29.0	100
Arc-2-Fin	114,325		131,000	0.81	20.0	53.8	54.0	100
Arc-2-Mid	114,000	115,375	131,750	0.87	16.4	35.5	37.6	100
Arc-3-Fin	117,625		136,375	0.86	19.3	51.8	49.8	100
Arc-3-Mid	119,500	121,000	137,725	0.87	15.0	31.0	39.2	100
Coupons Heat Treated to 225,000 T.S. Tempered at 400 F.								
Arc-1-Fin	173,875	186,375	229,250	0.76	10.2	38.2	17.4	30
Arc-1-Mid	124,375	143,750	197,875	0.63	1.2	2.4	12.9	14
Arc-2-Fin	171,875	183,625	216,500	0.80	12.0	33.8	13.8	23
Arc-2-Mid	126,250	144,125	193,250	0.65	3.8	9.2	14.3	12
Arc-3-Fin	175,250	188,250	230,500	0.74	8.0	33.6	15.0	24
Arc-3-Mid	123,375	143,500	193,250	0.64	2.3	4.6	11.9	11

TABLE 5 — MECHANICAL PROPERTIES OF Cr-Ni-Mo INDUCTION FURNACE STEEL (Heat No. Ind — 1, Coupons Tempered at 600 F)

Position	Y.S.—0.1%, psi	Y.S.—0.2%, psi	T.S., psi	0.1% Y.S. T.S.	Elong., %	R. A., %
Tensile Testing						
Fin	200,500	204,000	239,000	0.84	6.4	11.4
Fin	202,500	205,000	239,500	0.84	5.0	8.7
Mid-Wall	207,500	212,000	249,000	0.83	5.0	11.4
Mid-Wall	210,000	215,500	251,500	0.84	5.0	1.6
Center	203,500	211,000	230,000	0.88	0.7	1.6
Center	195,500	203,500	217,500	0.90	0.7	3.8

Charpy Impact (Ft-Lb) Data for Transition Curves

Temp. C(F)	Position Fin	Mid-Wall	Center
−40(−40.0)	9.2	6.4	6.4
	10.3		5.7
−20(−4)	7.8		6.4
	9.7		6.2
0(+32)	10.0	6.2	6.7
	11.8		6.7
+20(+68)	9.7	9.5	7.5
		9.5	7.5
+40(+104)	10.6	7.5	8.9
			9.5

ties identical to the fin properties, that is, a tensile strength of 225,000 psi, a 0.1 per cent yield strength of 175,000 psi, 10 per cent elongation, 35 per cent reduction in area and a −40 F impact resistance of 15 ft-lb.

The over-all outstanding combination of mechanical properties in the high strength fins is in large measure due to the inherent cleanliness of the arc furnace steel, and, in particular, to its low sulfur and phosphorus content < 0.010 per cent.[7,8]

Table 5 presents mechanical properties of induction melted steel of the same analysis as the arc furnace steel. The only chemical difference between the two is that the induction melt had a greater carbon content (0.09 per cent C) and also had higher sulfur and phosphorus content (approximately 0.007 per cent). Comparison of the high strength arc furnace fin data to the induction melt data indicates the general superiority of the arc furnace steel. This difference may be attributed to the sulfur and phosphorus differences or to the higher carbon content of the induction material.

Unfortunately, in order to make comparisons at equivalent strength levels, the induction melted steel was tempered at 600 F, and it can be inferred that the use of this tempering temperature caused some embrittlement.[9] This seems to be confirmed by data of Table 6 where the induction steel was tempered at a lower temperature (300 F) to yield a higher strength (270,000 psi) and increased ductility (20 per cent reduction in area).

The 500-600 F embrittlement can be overcome by silicon additions.[10] Table 7 gives results for coupons with the silicon addition and a 600 F temper. Properties are comparable to those of the chromium, nickel and molybdenum analysis in Table 6.

All of the induction steels developed differences in mechanical properties from the fin to midwall to center. In view of the drastic water quench employed, it seems unlikely that microstructural constituents usually associated with slack quenching could account for these differences. The yield-tensile strengths ratio remains fairly constant and indicates that the quench was effective.[6] Possible reasons for the difference between midwall and center properties have been discussed elsewhere.[11]

Interpretation of overall impact results is quite difficult, but some observations can be made. First, toughness decreases with increased strength; also, it decreases in going from the outside to the inside of the castings. On the other hand, the toughness required as insurance against complete brittle failure

TABLE 6 — MECHANICAL PROPERTIES OF Cr-Ni-Mo INDUCTION FURNACE STEEL (Heat No. Ind. — 1. Coupons Tempered at 300 F)

Position	Y.S.—0.1%, psi	Y.S.—0.2%, psi	T.S., psi	0.1% Y.S. T.S.	Elong., %	R. A., %
Tensile Testing						
Fin	194,500	209,000	274,000	0.72	9.3	22.6
Fin	195,500	209,500	280,000	0.70	8.6	19.1
Mid-Wall	200,000	214,500	283,500	0.70	5.7	9.3
Mid-Wall	197,000	211,500	283,500	0.70	5.0	8.2
Center	186,000	202,000	240,000	0.77	1.4	3.8
Center	182,000	198,000	236,500	0.77	2.9	5.5

Charpy Impact Data for Transition Curves

Temp. C(F)	Position Fin	Mid-Wall	Center
−40(−40.0)	7.0	4.2	4.2
	6.2	3.4	3.4
−20(−4)	7.0	5.4	5.2
	7.3	5.4	5.4
0(+32)	6.7	6.0	4.4
	7.3	5.4	4.7
+20(+68)	8.4	5.7	6.2
		6.2	5.4
+40(+104)	8.6	7.0	6.0
		6.7	5.0

TABLE 7 — MECHANICAL PROPERTIES OF SILICON MODIFIED INDUCTION FURNACE STEEL
(Heat No. Ind. — 3. Coupons Tempered at 600 F)

Position	Y.S.—0.1%, psi	Y.S.—0.2%, psi	T.S., psi	0.1% Y.S. T.S.	Elong., %	R. A., %
Tensile Testing						
Fin	216,500	228,500	270,000	0.80	6.4	16.6
Fin	218,500	231,500	272,000	0.81	5.7	13.5
Mid-Wall	213,000	226,000	266,500	0.80	4.3	9.8
Mid-Wall	217,000	230,000	268,500	0.80	2.1	6.0
Center	*	*	193,500		0.0	0.0
Center	204,000**	*	203,000		0.0	0.0

*Specimen broke before requested offsets obtained.
**Yield point by divider method.

Charpy Impact Data for Transition Curves

Temp. C(F)	Fin	Mid-Wall	Center
−40(−40.0)	8.6	5.7	3.2
	6.4	6.0	7.0
−20(−4)	9.5	6.4	6.7
	9.2	2.8	5.7
0(+32)	9.7	7.5	7.0
	11.8	7.3	7.3
+20(+68)	10.0	6.4	6.7
		7.3	8.6
+40(+104)	10.6	7.3	7.0
		9.2	7.8

(flow and fracture stress coincide) must increase with increased yield strength, for ability to absorb elastic energy also increases with the yield strength.

Even though the steels exhibited reasonable percentages of fibrosity in the Charpy test, the above reasoning leads to a conservative approach in the application of high strength steels. Performance tests of actual castings should be required, and then a practical toughness should be specified that is representative of successful test castings.

It is interesting to compare results of these coupon experiments with similar forging data taken in the transverse direction.[6] At low strength levels the equivalence of properties is well known. Comparison of the limited data available indicated the same equivalence seems to hold at high strength also.

The high strength program is not limited to coupon block castings, but also includes the manufacture of useful high strength castings. The data now presented on the drum cradle casting are typical of this. Table 8 shows mechanical properties resulting from various tempering treatments and the cradle manufacturing procedure outlined in Table 3. High tempering temperatures, in the 1200 F range, resulted in a strength level of 160,000 psi with a ductility of 35 per cent reduction in area and a −20 F impact energy of 29 ft-lb, while the processing technique with a low tempering temperature (775 F) yielded a strength of 215,000 psi, ductility of 15 per cent reduction in area and −20 F impact energy of 8.5 ft-lb. The higher strength properties represent a reasonable compromise between ductility, toughness and strength. Since tests were conducted on bars removed from actual castings, it is assumed that mechanical properties of castings submitted for service test are as shown in Table 8.

TABLE 8 — MECHANICAL PROPERTIES OF DRUM CRADLES
(Heat No. Ind. — 2. Average of 3 tests)

Y.S. −0.1%, psi	Y.S. −0.2%, psi	T.S., psi	0.1% Y.S. T.S.	El., %	R.A., %	−20 F Impact ft-lb	Fibrosity, %
A. Casting Tempered at 775 F							
201,333	204,333	217,667	0.92	5.7	15.0	8.5	18
B. Casting Tempered at 825 F							
186,333	189,000	197,000	0.94	3.5	13.0	10.5	23
C. Casting Tempered at 1175 F							
150,750	150,083	157,233	0.96	13.6	33.9	29.7	100
D. Casting Tempered at 1200 F							
152,667	152,500	161,133	0.94	13.3	35.0	28.1	100

SUMMARY

Cast test coupons were manufactured, heat treated and tested from arc furnace and induction melted steels. Data presented show the mechanical properties obtainable through various heat treating and testing procedures. The superiority of arc furnace practice is high lighted by presentation of data from coupon fins wherein a strength level of 225,000 psi is obtained with 35 per cent reduction in area and 15 ft-lb impact at −40 F. Thin-walled, high strength castings were manufactured, tested for mechanical properties and submitted for service testing. Small section size castings are quite feasible, but as section increases mechanical properties are lowered.

REFERENCES

1. *Investigation of Solidification of High Strength Steel Castings Under Simulated Production Conditions*, M.I.T., July 1, 1958, Contract Nr. DA-19-020-505-ORD-4511.
2. "Delayed Failure and Hydrogen Embrittlement in Steel," R. P. Frohmberg, W. J. Barnett and A. R. Troiano. *A.S.M. Transactions*, pp. 892-923, 1955.
3. "Optimum Operating Procedure for Basic Electric Steel Furnace for Desulphurization and Dephosphorization," *Journal of Steel Castings Research*, No. 8, pp. 12-16, May 1957.
4. "Tensile and Impact Properties of Low Carbon Martensite," C. C. Busby, M. F. Hawkes and H. W. Paxton, *A.S.M. Transactions, vol. 47*, pp. 135-156, 1955.
5. "Stepped Austenitizing Treatment for 4340 Steel," E. P. Klier, Volker Weiss and George Sachs, *A.I.M.E. Transactions, vol. 209*, p. 424-425.
6. "Effect of Silicon on Transverse Properties and on Retained Austenite Content of High Strength Steels," John Vajda, John J. Hauser and Cyril Wells, *A.S.M. Transactions, vol. 49*, pp. 517-549. 1957.
7. "Effect of Phosphorus and Sulfur Content on Ductility and Toughness of Cast Low Alloy Steels," J. Zotos, *Electric Furnace Steel Proceedings, A.I.M.E., vol. 15*, 1958.
8. "Low Temperature Impact Properties of Cast Steel," *Journal of the Iron and Steel Institute, vol. 187*, Part II, pp. 104-120, Oct. 1957.
9. "Embrittlement of Alloy Steel at High Strength Levels," L. J. Klinger, W. J. Barnett, R. P. Frohmberg and A. R. Troiano, *A.S.M. Transactions, vol. 46*, pp. 1557-1598, 1954.
10. "Some Effects of Silicon on the Mechanical Properties of High Strength Steels," C. H. Shih, B. L. Averbach and Morris Cohen, *A.S.M. Transactions, vol. 48*, pp. 86-116, 1956.
11. "Mass Effect on Castings Tensile Properties, a rationalization," G. W. Form, P. J. Ahearn and J. F. Wallace, AFS TRANSACTIONS, *vol. 67*, p. 65, 1959.

CORE BOXES FOR SHELL CORES

By J. E. Stock

ABSTRACT

The use of gray iron shell core boxes is discussed, showing reasons why the author's company uses this metal in preference to aluminum. Some of the provisions necessary when using gray iron are given as well as the use record of some of the boxes.

INTRODUCTION

There seems to be little said about core boxes for shell cores that finds its way into printed form to be published for the benefit of those interested in shell cores.

Probably due to the fact that throughout the foundry industry, each individual working on the shell sand method for cores is prone to think things out as he goes along, and as in most cases use the trial and error method of arriving at the solution of the problem or problems.

When we talk normally in terms of a ten year period of active interest in shell core and shell mold processes, we sometimes think that in ten years any intelligent person should know all there is to know about it. However, that is possibly true with many, but it has been found that in the foundry business at the end of a ten year period it is not uncommon to become confused about many issues. This is evident when you read the trade journals and find so many different opinions voiced on any one process or method.

These opinions are based on certain facts, and, therefore, are true when you know all the conditions from which the facts were obtained.

The one outstanding fact is that each one of us here is a little bit different than each other in more than one respect. The same applies to our respective foundries, no two are exactly alike even though the basic fundamentals of foundry practice are still observed.

SHELL CORE EQUIPMENT

Equipment for making shell cores is a subject that is important in many ways. There are those who wish to redesign the foundry to fit the equipment, and there are those who wish to have the equipment designed to fit the foundry. Both have their place depending upon what is best suited to the particular application.

Before you can decide what you want in the type of core box you must first decide what type of machine you are going to use. Of course, you do not need a machine to make shell cores, they also can be made on a bench, simply heat the boxes and take them apart by hand.

METAL USED

When the decision is made to provide a core box for making shell cores it will have decided what type of metal is to be used to fit the needs. Shell core boxes can be made of several metals, iron, steel, bronze, aluminum and possibly some other combinations.

At the author's company gray iron is used for all shell core boxes as well as shell mold patterns, and both are made by the "cast to size" method. The reason is simple, we have the gray iron and what we think is a satisfactory and most economical method of making the core boxes. We are also well satisfied with the results obtained from the use of gray iron core boxes. We have used cast aluminum shell core boxes with varying results.

The main objection to aluminum was the co-efficient of expansion characteristics when subjected to temperatures up to 600 F differ somewhat from those obtained by use of gray iron at the same temperature. If we were to say that the rate of heat transfer in aluminum core boxes is twice as rapid as that of gray iron core boxes then the dissipation rate should follow the same line.

This has an appreciable effect on the cycle time on a given machine to produce a quality shell core whether it is to be drained hollow, or made solid.

ALUMINUM CORE BOXES

Experience has shown that when using aluminum core boxes on several shell core machines, the machines can be operated on shorter cycles than when using gray iron boxes on the same machine, and at higher temperatures. However, on multiple station machines where there are six different sizes and shapes of cores being made at the same time and temperature, not all of the cores were cured exactly the same. Some cores because of their design were

J. E. STOCK is Supt. of Foundry Methods and Processes, John Deere Waterloo Tractor Works, Waterloo, Iowa.

good, others having several right angle sections were subject to insufficient cure and peel back occurred.

Warpage was encountered in the aluminum shell core boxes after the first 30 days they were on the machines.

The use of aluminum shell core boxes has been discontinued at the author's company, and gray iron boxes are being used. To begin with the core boxes were made solid. Then, in order to provide for better heat transfer to all sections of the core cavity the back was hollowed out, and metal wall sections of a thickness to insure uniform temperature to all sections were provided. In some cases it was necessary to provide for copper inserts at some sections to provide an excess of heat to a given area to properly cure.

CORE BOX EXPANSION PROVISION

It is necessary and of great importance in making the patterns for the core boxes that, in addition to providing for normal shrinkage of the metal, consideration be given to the normal expansion of the metal box when heated, otherwise a core that is larger than desired will be obtained.

Shell core boxes can be designed with a minimum of draft, and in some cases no draft. Proper rigging of shell core boxes is important, especially when used in high production. Proper breaking of shell core boxes can eliminate a lot of lost time and scrap cores.

Venting shell core boxes can present quite a problem in some instances. Wherever possible slotted or screen blow vents should be avoided. A practical vent that works well is to drill a hole in the area to be vented and insert a square pin to provide vent area on four sides. This type of vent cannot fall out as do some of the common blow vents, due to the contraction and expansion occurring when boxes are subjected to variations in temperature.

One of the most desirable methods of venting shell core boxes has been accomplished by milling slots in the parting of the boxes adjacent to the area to be vented. These slots may be of a depth that is suitable to the type of core sand used. They should allow for the air to escape and not the sand. The slots do not necessarily have to be milled to the outside of the box at the parting line, but should be approximately ½-in. outward from the cavity, and a hole of small diameter could be drilled from the slot through the box to the outside. This is a matter of preference.

For removal of cores from the boxes the core boxes should be well treated with a release agent before use, and in many cases the use of an ejection system is necessary.

CORE BOX RIGGING

Proper rigging of core boxes to provide efficient operations for blowing, curing and ejection of cores is of the utmost importance regardless of whether it is for high or low production rates.

Analysis of the gray iron used in the cast to size core boxes at the author's company is as follows:

Carbon.....320 - 340	6 to 9 mm chill depth
Silicon .....220 - 240	on a wedge type speci-
Sulfur 0.15	men 1⅝-in. high by
Phosphorus ..0.20	½-in. base.
Manganese...0.65	

All gray iron core boxes are subject to a HT5 stress relief before machining. To date the author's company has approximately 300 gray iron core boxes producing shell cores that have been in use over the past four years. These core boxes have been subjected to heat variations from ambient or room temperature up to 600 F.

Some are in production for 2 or 3 hr, and others have operated for 24 hr for six days without allowing to cool.

Based on past experience all shell core boxes and/or patterns required in the future will be made of gray iron.

TIN EFFECT ON STRUCTURE AND PROPERTIES OF FLAKE AND NODULAR GRAPHITE CAST IRONS

By E. C. Ellwood

ABSTRACT

The paper reviews previous work on the effect of tin on flake and nodular graphite cast irons. New results on the effect of tin on the promotion of pearlite matrices in two nodular irons are presented. The tin effect on the mechanical properties of such irons is discussed.

INTRODUCTION

Over the past few years, work which has been published shows that tin has a marked effect on the structure and properties of cast iron. In particular, it affects the stability of eutectoid cementite and promotes the formation of pearlite in the matrix of cast iron. This latter effect is not accompanied by any great risk of the formation of proeutectoid cementite, so that by tin additions a completely pearlitic matrix may be obtained without risk of the formation of hard spots.

PREVIOUS WORK

Tin in Flake Graphite Cast Irons

De Sy and Foulon[1] carried out a limited investigation on the effect of tin on the matrix of flake graphite iron as a corollary on their investigation of tin in nodular iron. The iron chosen contained nearly 4 per cent carbon, and approximately 2 per cent silicon, in a substantially phosphorus-free base. Without treatment, the iron solidified with coarse graphite flakes surrounded by sheaths of ferrite, which comprised about 20 per cent of the volume of the matrix.

With 0.020 per cent residual tin, traces of free ferrite remained, and with 0.048 per cent tin, a completely pearlitic matrix was obtained. This work established that tin is a pearlite promoter in gray iron. However, before its use for this purpose could be established, information on the mechanical properties of iron containing small amounts of tin was required. In an investigation sponsored by the Tin Research Institute at Battelle Memorial Institute, Davis, Krause and Lownie[2] studied the effect of tin in cast iron in rather more detail, paying particular attention to its effect on the mechanical properties.

Their experiments were carried out on an automotive-type hypoeutectic, and a general-purpose hypereutectic gray iron. The Brinell hardness for both irons increased with increasing amounts of tin up to 0.5 per cent. The tensile strength in 1.2-in. diameter bars increased with tin content up to about 0.2 per cent, and levelled off as more tin was added. The transverse strength of the two irons was affected differently by tin.

The transverse strength of the general-purpose irons was markedly increased by tin contents of 0.1 and 0.2 per cent, while that of the automotive-type iron was unaffected. The deflection in the transverse test, and the impact strength of unmachined 1.2-in. diameter bars, increased slightly when about 0.05 per cent tin was added, and then fell off with increasing amounts of tin.

The effect of tin upon the stress-strain relationship in the two types of cast iron was also studied. It was found that the modulus of elasticity for the automotive-type iron was increased by about 5 per cent. For the soft hypoeutectic iron, 0.08 per cent of tin reduced the modulus of elasticity slightly (but not consistently), and increased the tensile strength by about 16 per cent. In both cases, the effect on the stress-strain curve was small from a practical point of view, but it is interesting that tin was beneficial rather than harmful.

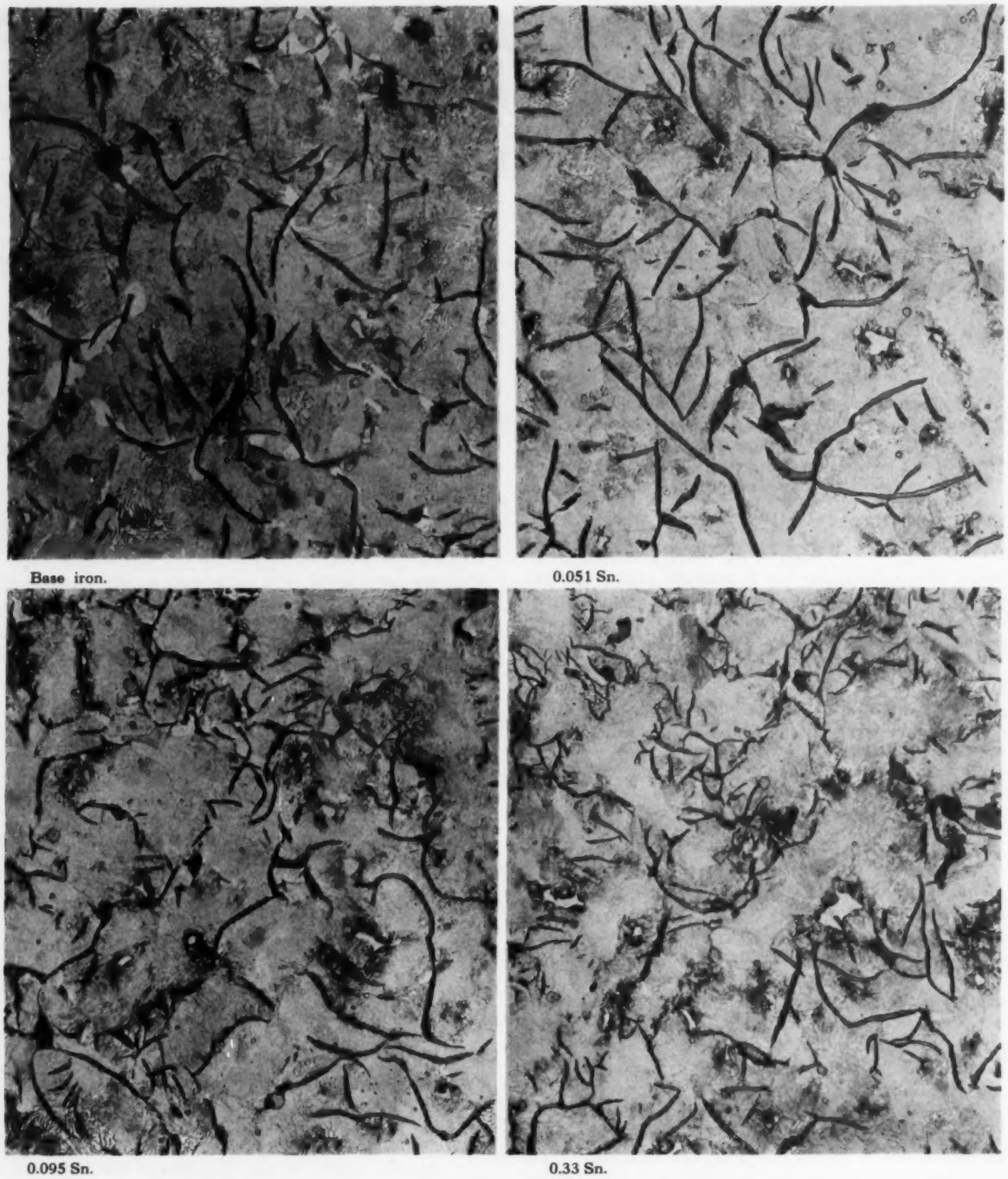
Impact Strength Test

The effect of tin on the impact strength of the irons was investigated in more detail. Test bars of 1.5, 1.125 and 0.75 in. diameter were machined from cast bars of 2.0, 1.2 and 0.875 in. diameter, respectively, and were tested for impact strength in the unnotched condition in a Charpy-type test. The impact strength increased slightly with small additions of tin. In both types of iron, and in the three sizes of bars tested, the impact strength of the iron containing 0.1 per cent tin was no lower than that of the base iron.

At the same time, tin had no deleterious effect on the impact strength until after massive ferrite was substantially eliminated from the microstructure. Therefore, tin was shown to be embrittling only in amounts exceeding those required to obtain the desired microstructure.

This work showed that for the automotive hypoeutectic iron, the percentage of pearlite in the matrix increased from about 80 per cent with no tin, to almost 100 per cent with 0.051 per cent tin (Fig. 1). With the hypereutectic iron, about 0.2 per cent tin was required to obtain a substantially pearlitic ma-

E. C. ELLWOOD is Chief Met., Tin Rsch. Institute, London, England.



Base iron. 0.051 Sn.

0.095 Sn. 0.33 Sn.

Fig. 1 — Microstructures of hypoeutectic cast iron in 1.2 in. diameter bars. Base iron composition — 3.33 C; 2.08 Si; 0.64 Mn; 0.108 P; 0.096 S. 250×.

trix, but in this case the base iron contained about 55 per cent ferrite (Fig. 2). These results were obtained on test bars 1.2 in. in diameter, but it was shown that similar amounts of ferrite and pearlite were obtained in test bars 0.875 in. and 2.0 in. in diameter for the same tin content.

It was also shown that tin additions considerably in excess of the optimum amounts necessary to produce a fully-pearlitic matrix did not result in the formation of massive carbides in the microstructure.

The effect of tin upon the amount of pearlite in gray iron is of practical significance because of the known wear resistance of fully-pearlitic iron. Pearlitic structures may also be obtained by the addition of conventional alloying elements such as vanadium or chromium, but these additions have the undesirable feature that small excesses cause massive carbides to appear in the microstructure. In contrast to this, rea-

sonable excess of tin does not promote the formation of massive carbides.

As a complement to the laboratory investigation, the effect of tin on the microstructure and mechanical properties of gray iron was also determined in several commercial foundries. Additions of tin had about the same effect on mechanical properties and microstructure of commercial cast iron melted in cupolas as was obtained in cast iron melted and tested in the laboratory.

Tin in Nodular Cast Iron

In their original patent application, Millis, Gagnebin and Pilling[3] listed tin, lead, antimony, bismuth, arsenic, selenium and tellurium as subversive elements which interfere with the production of nodular graphite structures. Tin was singled out as being particularly detrimental, and it was recommended that it should not be allowed to exceed 0.05 per cent.

Morrogh[4] investigated the effects of some of the

Base iron.

0.058 Sn.

0.092 Sn.

0.33 Sn.

Fig. 2 — Microstructures of hypereutectic cast iron in 1.2 in. diameter bars. Base iron composition — 3.70 C; 2.45 Si; 0.65 Mn; 0.134 P; 0.101 S. 250×.

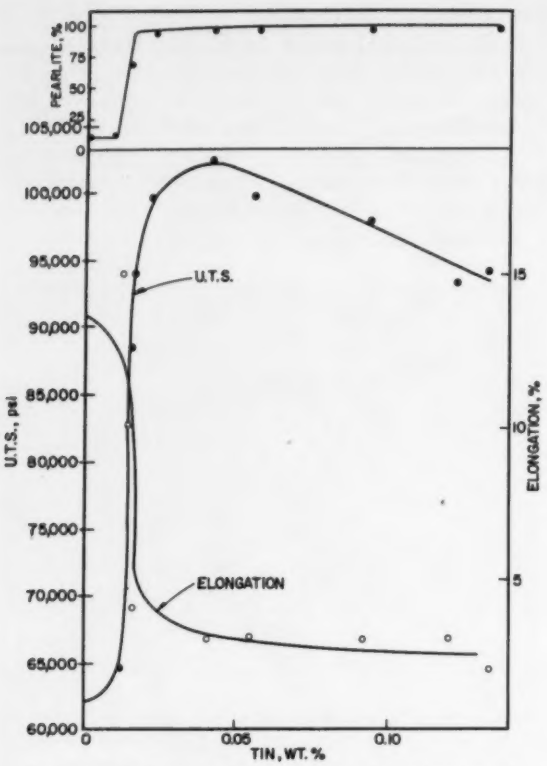


Fig. 3 — Tin effect on the structure and properties of nodular iron.[4]

so-called subversive elements on the structure and properties of nodular irons, and found that up to 0.13 per cent tin had no effect on the shape of the graphite nodule. However, addition of tin had a profound effect on the stability and occurrence of pearlite. An iron, the matrix of which was substantially ferrite without tin, may be transformed completely to pearlite by the addition of relatively small quantities of tin. This modification of the structure is naturally accompanied by considerable changes in mechanical properties.

Tin Effect on Properties

These are shown in Fig. 3, from which it will be seen that increasing the tin from zero to 0.041 per cent changed the matrix from 90 per cent ferrite to 100 per cent pearlite. Corresponding with this is an increase in tensile strength and hardness from 62,500 to 102,000 psi, and from 158 to 253 Brinell hardness, respectively, with a decrease in elongation from 15 to 3 per cent. Where maximum ductility is required, this change is undesirable, but where high-strength, wear-resisting engineering castings with reasonable shock resistance are required, 100,000 psi tensile with 3 per cent elongation is quite attractive.

Further additions of tin above that required for a completely pearlitic structure cause slight deterioration in tensile properties and some increase in hardness. However, it appears that up to three times the optimum amount of tin can be added without serious effects. Morrogh did not report massive cementite in the microstructure of iron when three times the tin required for a completely pearlitic structure was added. He clearly showed that the separation of the graphite as nodules was not affected by tin contents up to the maximum studied (i.e., 0.13 per cent).

While Morrogh's results were obtained incidentally to an extended research on the effect of several elements on the formation of nodular graphite in irons with a substantially pearlitic matrix, de Sy and Foulon[1] adopted a different approach. Although they did not wish to minimize the range of applications for which it is necessary to demand maximum ductility, they thought that the general tendency had been to exaggerate in this regard.

They contended, on the other hand, that the applications of pearlitic nodular graphite cast irons did not seem to have received sufficient attention, and considered that pearlitic nodular iron constituted a structural material of great interest, especially where resistance to wear was required. As a consequence, their investigation was aimed specifically at the attainment of nodular iron free from ferrite or cementite.

Manganese Content

In the first place, they investigated the possibility of obtaining the desired structure by variations in the manganese content. In the particular iron used, they found that free ferrite was still obtained with 1.33 per cent, and free cementite was produced by 1.47 per cent of manganese. Thus, while it was undoubtedly possible to get the desired results, the useful range of manganese content appeared to be inconveniently narrower than would be desired in usual foundry practice.

Since manganese is the least effective of the recognized carbide-formers, they concluded that the difficulty in obtaining the exact transition structure between pearlite and ferrite on the one hand, and pearlite and cementite on the other, would increase if stronger carbide-forming elements than manganese were used. Consequently, they turned their attention to nickel, copper and tin.

Under their experimental conditions, they found that the percentage of ferrite diminished with increase in nickel content, and became stable at around 10-20 per cent with about 2.5 per cent of nickel. Further additions of nickel did not decrease the volume of ferrite appreciably, and the matrix became self-hardening.

With copper, an addition of 0.8 per cent gave a completely pearlitic matrix and corresponded with maximum tensile strength. Larger additions caused a fairly sharp decrease in strength, which was associated with a degeneration in the surface regularity of the graphite nodules. No massive cementite was formed. With 3.2 per cent of copper, the graphite nodules were no longer recognizable as such and considerable loss in strength resulted.

The results from tin obtained by these authors were in good agreement with those of Morrogh. They found that additions of 0.03 per cent were sufficient to ensure a pearlitic matrix, and give an increase in tensile strength from 59,800 to 96,000 psi with a corresponding decrease in elongation from 13 to 3 per cent. Further increase in tin content did not produce

any free carbide in the microstructure, but tensile properties decreased and became rather more erratic than those obtained by Morrogh.

The promise of these results induced the Tin Research Institute to sponsor an investigation at Battelle Memorial Institute on the effect of tin on the microstructure and more important mechanical properties of nodular iron. The results of this investigation carried out by Williams, Keyser and Lownie[5] are reported herein.

EXPERIMENTAL

After preliminary experiments on small melts, two compositions of nodular cast iron, shown in Table 1, were selected for study. These compositions gave base irons with significantly different amounts of pearlite in the microstructure. Base iron *A* contained 71 per cent pearlite, and base iron *B* 58 per cent pearlite in a 1-in. Y-block.

A 600-lb melt of each of the two compositions was made in an induction furnace from low-sulfur and low-tin stock. Parts of these melts were drawn off and alloyed with 0.00, 0.04, 0.036, 0.050, 0.13 or 0.37 per cent of tin, each portion being treated subsequently with nickel-magnesium nodulizing agent, cerium and an inoculating addition of ferrosilicon in the normal manner. The treated melts were used to prepare A.S.T.M. standard Y-block castings measuring 0.5, 1.0 or 3.0 in. in the test section.

Each Y-block casting was sectioned as described in A.S.T.M. specification A.396-56-T. The sections were used for metallographic and mechanical-test specimens. The proportions of the micro-constituents were determined accurately on a number of samples, which were subsequently used as standards from which the proportion of ferrite in the remaining samples was determined by comparison. Brinell hardnesses were determined on the top inside surface of sections cut from Y-blocks. All other mechanical tests were made on duplicate tensile specimens as described in A.S.T.M. A.396-56-T. No heat treatment was carried out before testing.

Tin Effect on the Iron Matrix

Microstructures obtained when each of the base irons was alloyed with various amounts of tin, and cast into Y-blocks of different sections, are described in Table 2. With no addition of tin, base iron *A* contained 67.5 per cent to 71.5 per cent pearlite. With about 0.05 per cent of tin, the pearlite in this iron increased to about 95 to 97 per cent of the matrix. In base iron *B*, matrices containing 57.5 to 63 per cent pearlite were changed to contain 90 to 95 per cent of pearlite with the same tin addition.

Above about 0.05 per cent of tin, additional amounts had less effect than at lower levels of tin. The removal of the last traces of ferrite generally required about 0.1 to 0.2 per cent tin. Removal of the last traces of ferrite was more difficult in base iron *B*, which contained higher initial quantities of ferrite, than in base iron *A* (Figs. 4 and 5).

The effects of tin in both irons were relatively insensitive to section thickness. The castings 0.5 and 1.0-in. thick behaved in about the same way, and the 3.0-in. castings required only a little little more tin to make them completely pearlitic. The Y-block 0.5-in. thick contained more massive cementite, but this occurrence bore no relation to the amount of tin used. The cementite in the thin sections was probably the result of insufficient inoculation during the manufacture of the base iron.

The inoculating addition was calculated on the basis of the 1.0-in. Y-blocks, and appears to have been

TABLE 1 — CHEMICAL COMPOSITION OF TWO BASE NODULAR IRONS ALLOYED WITH TIN

Element	Base Iron A (71 per cent of Pearlite)[a], %	Base Iron B (58 per cent of Pearlite)[a], %
Carbon	3.52	3.42
Silicon	2.37	2.58
Manganese	0.51	0.42
Phosphorus	0.023	0.023
Sulfur	0.017	0.017
Nickel	0.42	0.42
Tin	0.003	0.003
Cerium	0.006[b]	0.006[b]
Magnesium	0.05[b]	0.05[b]
Carbon Equivalent (T.C. + ⅓ Si + ⅓ P)	4.31	4.28

[a] Measured in unalloyed 1-in. Y-block.
[b] Cerium and magnesium contents were estimated from recoveries obtained in preliminary heats.

TABLE 2 — MICROCONSTITUENTS IN MATRIX OF TWO DIFFERENT NODULAR IRONS ALLOYED WITH TIN IN CAST SECTIONS 0.5, 1.0 AND 3.0 IN. THICK

Base composition, %	Tin content, %	Microconstituents in 0.5-in. section, % of matrix			Microconstituents in 1.0 in. section, % of matrix		Microconstituents in 3.0 in. section, % of matrix	
		Pearlite	Ferrite	Massive Cementite	Pearlite	Ferrite	Pearlite	Ferrite
				Base Iron A				
3.52 C	0.003	69.0	24.0	7.0	71.0	29.0	67.5	32.5
2.37 Si	0.014	77.0	15.5	7.5	73.0	27.0	72.5	27.5
0.51 Mn	0.036	90.5	6.7	2.8	94.0	6.0	85.0	15.0
	0.05	96.0	4.0	0.0	97.0	3.0	95.0	5.0
	0.13	100.0	0.0	0.0	100.0	0.0	98.0	2.0
	0.37	95.0	0.0	5.0	100.0	0.0	100.0	0.0
				Base Iron B				
3.42 C	0.003	62.5	31.7	5.2	57.5	42.5	63.0	27.0
2.58 Si	0.014	72.5	27.5	0.0	64.0	36.0	61.0	29.0
0.42 Mn	0.036	88.4	11.6	0.0	86.0	14.0	75.0	25.0
	0.05	95.0	3.0	2.0	90.0	10.0	90.0	10.0
	0.13	98.0	3.0	0.0	98.0	2.0	96.0	4.0
	0.37	98.0	0.0	2.0	100.0	0.0	100.0	0.0

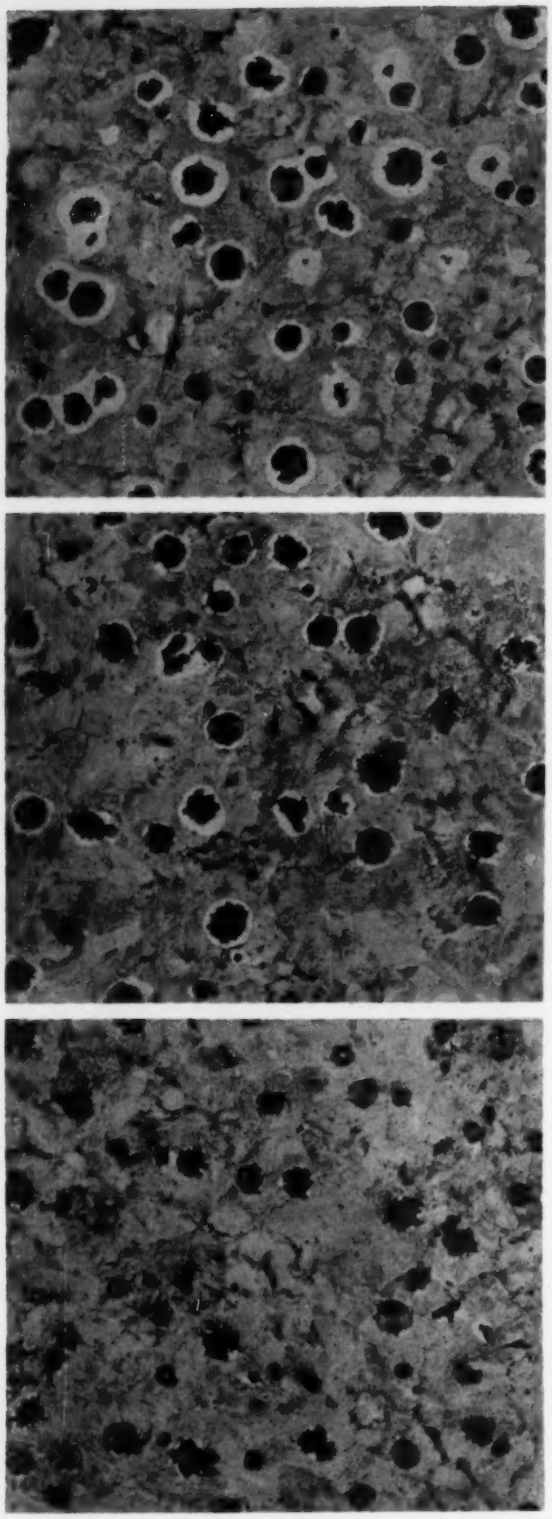


Fig. 4 — Microstructures of nodular cast iron *A*. Base iron composition — 3.52 C; 2.37 Si; 0.51 Mn; 0.023 P; 0.017 S; 0.42 Ni. 100×. Top: Base iron — 0.003 Sn, 29 per cent ferrite; center: 0.036 Sn, 6 per cent ferrite; bottom: 0.05 Sn, 3 per cent ferrite.

insufficient to prevent chill in the smaller blocks. It is particularly significant that in the 0.5-in. sections, which were found to produce massive cementite when only the residual tin content of the base iron was present, even large additions of tin did not increase this tendency. Tin, therefore, was shown to be highly effective in increasing the amount of pearlite in the matrix without causing the formation of massive cementite.

The minimum amount of tin required to produce a completely pearlitic matrix for each iron and section size is plotted graphically in Fig. 6.

Tin Effects on Mechanical Properties

The major mechanical properties of the two nodular irons containing various amounts of tin are given in Table 3. For a given thickness of casting and a given base iron, the Brinell hardness increased with increasing amounts of tin. The increasing hardness was appreciable with additions of up to 0.05 per cent of tin which are required to give a substantially pearlitic matrix. With additions beyond this amount, the hardness increased only gradually.

The effect of tin was about the same for all three sizes of sections studied, although the hardness at a particular level of tin increased as the size of the section decreased. This effect on section size applied equally to the base irons without tin additions and was normal in cast iron.

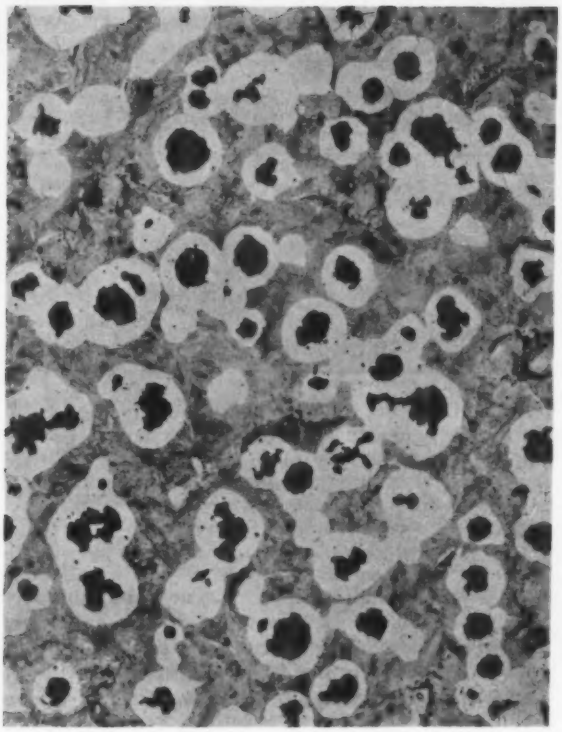
The results of tensile tests at various levels of tin showed that the tensile strength of the nodular irons under investigation increased to a maximum with increasing amounts of tin, and then decreased as more tin was added. Only when the amount of tin added exceeded the minimum required to obtain a pearlitic matrix was the tensile strength of the iron less than optimum.

Stress-strain data for nodular irons alloyed with tin were determined on tensile specimens cut from 1.0-in. Y-blocks. Tensile, modulus of elasticity and yield strengths were determined only for the base composition, and for the levels of tin nearest the minimum amount required to produce a completely pearlitic matrix. The results obtained are shown in Table 4, from which it will be seen that with amounts of tin sufficient to produce the required matrix, significant increases in the tensile modulus of elasticity and yield strengths of the iron were produced.

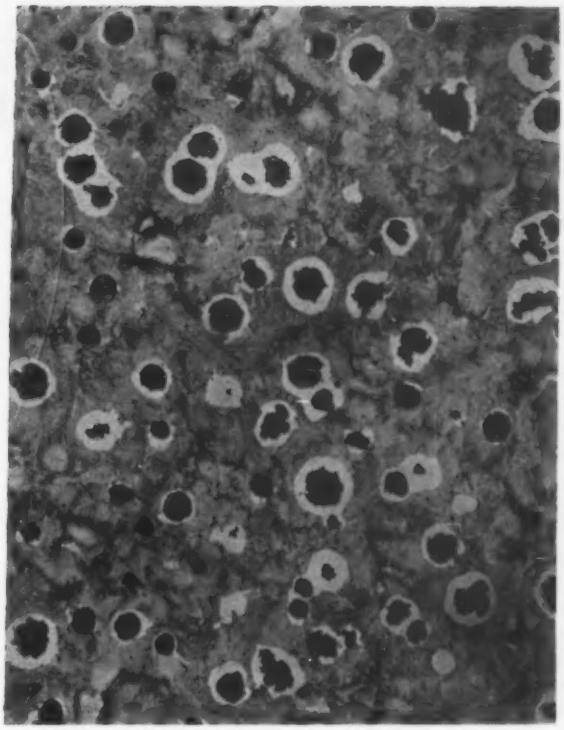
Tin Effect on Formation of Spheroidal Graphite

Tin is widely reported to be a subversive element which interferes with the formation of spheroidal graphite. Cerium is widely used to neutralize any subversive effects of small amounts of elements normally found as residuals in pig iron and high-quality scrap. It is important to recognize that in this investigation as little as 0.006 per cent of residual cerium was completely effective in neutralizing the potential subversive effect of as much as 0.37 per cent of tin.

From this it is apparent that useful amounts of tin may be added to nodular iron, with no more attention to its subversive effects than is required for any nodular iron. In addition, all the amounts of tin used in this investigation had no obvious effect on



Base iron, 0.003 Sn, 42 per cent ferrite.



0.036 Sn, 14 per cent ferrite.

Fig. 5 — Microstructures of nodular iron *B* in 1-in. section. Base iron composition — 3.42 C; 2.58 Si; 0.42 Mn; 0.023 P; 0.0175 S; 0.42 Ni. 100×.

TABLE 3 — TIN ADDITIONS EFFECTS ON MAJOR MECHANICAL PROPERTIES AND MICROSTRUCTURE OF NODULAR IRONS CAST INTO DIFFERENT SIZE Y-BLOCKS

Section Thickness, in.	Composition, %				Mechanical Properties			Microstructure		
	T.C.	Si	Mn	Sn	Tensile Strength, psi	Elongation[a] %	Bhn	Pearlite, %	Ferrite, %	Cementite, %
					Base Iron A					
3	3.52	2.37	0.51	0.003	97,500	8.1	220	68	32	—
				0.014	99,750	8.1	226	72	28	—
				0.13	106,750	4.0	258	98	2	—
				0.37	89,250	1.2	280	100	—	—
					Base Iron B					
	3.42	2.54	0.42	0.003	98,000	8.4	220	63	27	—
				0.13	103,750	2.4	265	96	4	—
				0.37	84,750	1.6	287	100	—	—
					Base Iron A					
1	3.52	2.37	0.51	0.003	99,250	6.8	224	71	29	—
				0.05	115,250	4.6	260	97	3	—
				0.13	114,500	3.3	267	100	—	—
				0.37	96,250	1.3	296	100	—	—
					Base Iron B					
	3.42	2.54	0.42	0.003	96,250	7.2	216	58	42	—
				0.13	103,500	2.2	278	98	2	—
				0.37	88,500	1.2	297	100	—	—
					Base Iron A					
½	3.52	2.37	0.51	0.003	99,000	5.5	249	69	24	7
				0.05	124,500	6.0	280	96	4	—
				0.13	126,000	5.0	282	100	0	—
					Base Iron B					
	3.42	2.57	0.42	0.003	97,500	6.5	250	62	33	5
				0.13	125,000	3.5	282	97	3	—
				0.37	88,000	1.0	317	98	0	2

[a] Elongation in 1 in. for specimens ½-in. thick. Elongation in 2 in. for specimens 1 and 3 in. thick.

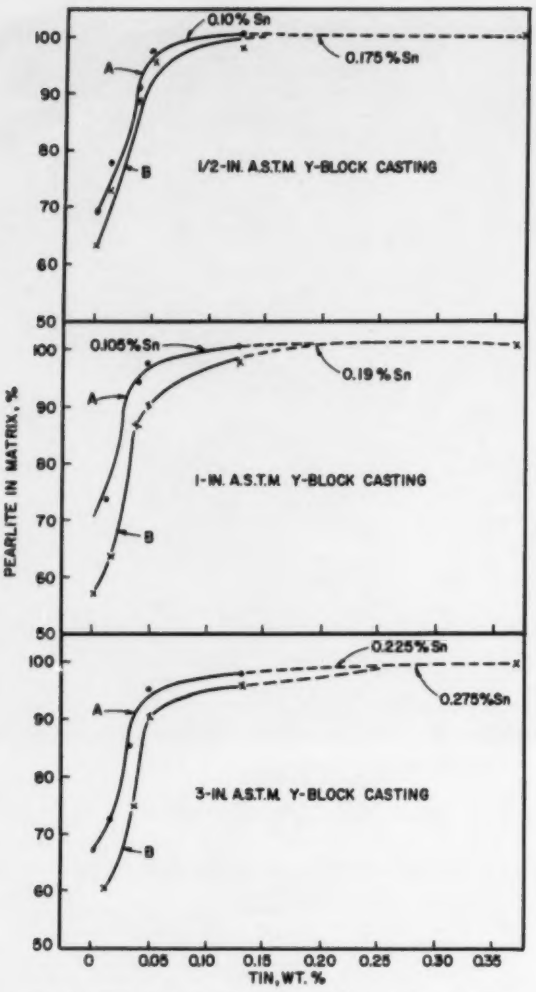


Fig. 6 — Tin content effect on matrices of two nodular irons cast in three different sized A.S.T.M. Y-Block castings. Line A composition — 3.52 C; 2.37 Si; 0.51 Mn. Line B composition — 3.42 C; 2.58 Si; 0.42 Mn.

TABLE 4 — EFFECT OF TIN ON THE TENSILE MODULUS OF ELASTICITY AND THE YIELD STRENGTH OF TWO NODULAR IRONS CAST INTO 1-IN. Y-BLOCKS

Base Iron Composition, %	Tin Content, %	Pearlite in Matrix, %	Tensile Modulus of Elasticity, psi	Yield Strength (0.2 per cent Offset), psi
		Base Iron A		
3.52 C	Residual (0.003)	71	22,700,000	56,500
2.37 Si				
0.51 Mn	0.13	100	24,900,000	67,750
		Base Iron B		
3.42 C	Residual (0.003)	58	24,400,000	57,750
2.54 Si				
0.42 Mn	0.13	98	26,200,000	85,500

the handling or foundry properties of the irons. Thus, the material containing tin handled, poured and behaved in about the same manner as the base iron to which tin had not been added.

SUMMARY

Tin had a marked effect in eliminating ferrite from the matrix of both gray and nodular irons. At the same time, tin, in amounts in excess of that required to promote a completely pearlitic matrix, did not lead to the formation of massive cementite. It has been shown that tin in amounts sufficient to give a substantially pearlitic matrix in gray iron, did not have any detrimental effect on the mechanical properties. Recent work showed the same to be true of nodular iron. Tin had no effect on the form of the graphite nodules in castings up to a 3-in. section.

REFERENCES

1. A. de Sy and J. Foulon, Twenty-first International Foundry Congress, Sept. 1954, *Metallurgia Italiana, 47*, (9), p. 421, 1955.
2. J. A. Davis, D. E. Krause, and H. W. Lownie, Jr., AFS TRANSACTIONS, *65*, p. 590, 1957.
3. K. D. Millis, A. P. Gagnebin, and N. B. Pillings; U.S. Patent No. 2,485,760.
4. H. Morrogh, *J. Research and Dev., B.C.I.R.A.*, April 1952.
5. R. C. Williams, N. H. Keyser and H. W. Lownie, Jr., Private communication.

CYCLIC PERMANENT MOLD OPERATION

some thermal aspects

By C. L. Goodwin and H. Y. Hunsicker

ABSTRACT

An experimental program was undertaken to determine the influence of mold section thickness, casting section thickness and operating rate on mold temperatures and time required for solidification of aluminum castings in permanent molds. These relationships were examined under dynamic conditions by repetitively casting rectangular aluminum alloy plates in coated cast iron molds of uniform section. The molds were cooled only by normal convection, conduction and radiation to the atmosphere.

Data developed in the investigation demonstrate certain fundamental principles and provide information which can be applied to the design and operation of permanent molds. It was found that mold temperatures, casting solidification rates and permissible speeds of operation are influenced considerably more by casting thickness than by mold thickness. However, operating characteristics can be changed significantly by varying mold thickness. For any selected production rate mold temperatures will be lower and solidification more rapid in thick molds than in thin molds. For a specified solidification rate, higher production is possible in thicker molds. These advantages may be partially offset, however, by handling and operating difficulties associated with thicker molds.

INTRODUCTION

Developments in the field of mechanized and precisely timed permanent mold equipment have increased the need for knowledge of the thermal aspects of the permanent mold process. Permanent molds are normally operated on a cyclic basis so that thermal relations of interest are dynamic in character. Knowledge of temperature conditions conducive to optimum production efficiency probably lags well behind the advances which have been made in mechanical equipment.

In a complete thermal analysis of permanent mold operation, consideration would have to be given to casting geometry, mold design, mold material, methods of cooling or heating, mold coating composition and thickness and length of operating cycle. The interrelation of these factors makes it difficult to rationalize the overall effects of changes in one variable, and has led to interesting discussions among permanent mold foundrymen. For example, all agree that a thin mold heats more rapidly than a thick mold when a casting is poured.

However, the thin mold cools more rapidly after the casting is removed from the mold. These observations lead to the conclusion that cyclic temperature fluctuations of thin molds exceed those of thick molds. It is difficult, however, to predict whether, with the same conditions of operation, a thick or thin mold will maintain a higher mean temperature. Similarly, the effect of mold temperature fluctuations on solidification of castings cannot be readily analyzed.

This difficulty of analytically determining the casting or mold geometry effects on permanent mold operation made a direct experimental approach to the problem necessary. An investigation embracing all possible variables would be prohibitively long. The scope of the present program thus was limited to determining, for castings and molds of simple shape, the influence of mold thickness, casting thickness and mold operating rate on mold temperatures and casting solidification times. While heat transfer was the fundamental consideration, it was obvious that factors of a metallurgical nature also were involved.

EQUIPMENT AND PROCEDURE

The experimental mold equipment consisted essentially of five sets of rectangular cast iron plates and five cavity spacers. The general arrangement of a typical plate and spacer combination is shown in Fig. 1. The spacers, which completely defined the size of the casting cavity, were interchangeable and could be mounted between any one of the five sets of mold plates.

Dimensions of the spacers and mold plates permitted the production of 0.25, 0.50, 0.75 and 1.50 in. thick castings in molds with walls 0.5, 1.0, 1.5, 2.0 and 3.0 in. in thickness. All the cavity spacers, and all the castings, were approximately 15 in. long and 6¼ in. high. The molds were mounted in an opening device actuated by compressed air. Metal was poured into the mold cavity through the central portion of the open upper edge.

An 0.004 in. thick refractory mold coating was ap-

C. L. GOODWIN and H. Y. HUNSICKER are with Aluminum Co. of America, Cleveland.

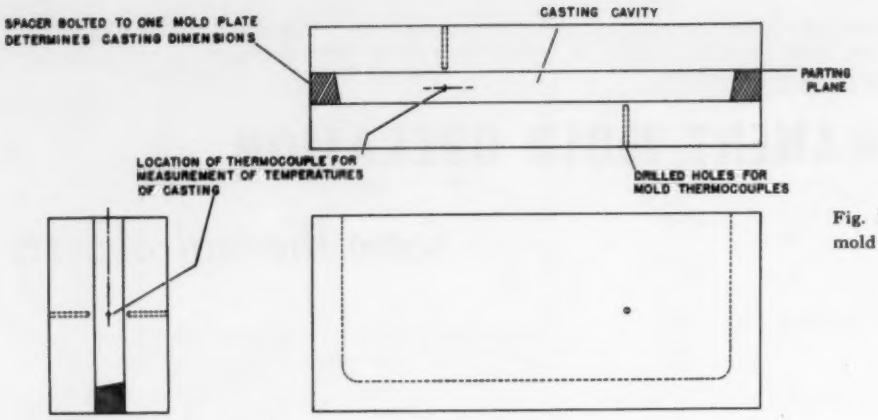

SPACER BOLTED TO ONE MOLD PLATE DETERMINES CASTING DIMENSIONS
CASTING CAVITY
PARTING PLANE
LOCATION OF THERMOCOUPLE FOR MEASUREMENT OF TEMPERATURES OF CASTING
DRILLED HOLES FOR MOLD THERMOCOUPLES

Fig. 1 — Sketch of experimental mold equipment.

plied to all cavity surfaces. Since small variations in coating thickness have a large influence on the chilling capacity of permanent molds, it was necessary to adjust this variable carefully. A magnetic thickness gage was used for controlling the coating thickness.

Temperatures in each of the mold plates were obtained with 26 gage chromel-alumel thermocouples located 1/8-in. from the mold-casting interface. Temperatures in the casting were observed by allowing similar thermocouples to solidify in the metal. Note in Fig. 1 the thermocouple in the casting was located adjacent to one of the mold thermocouples.

Thermal Considerations

All thermocouples were located so that the recorded temperatures would not be influenced by localized thermal conditions near the edges of the casting or adjacent to the metal entrance. The potentials developed by the thermocouples were recorded directly as temperatures on a high speed recorder. Thermocouples in the two mold plates were connected in parallel, and thus an average temperature for the two mold halves was recorded.

It was recognized that the alloy used in the investigation would have an influence on thermal conditions. Alloy 356 was selected because its solidification characteristics were considered representative of many alloys used in production.

The experimental procedure consisted of mounting a particular mold-cavity combination in the opening device, and then pouring castings at arbitrarily selected but fixed time intervals. Cyclic casting was continued until the system attained a state of dynamic thermal equilibrium as judged by the repetitive sequence of mold temperatures appearing on the recorder. When equilibrium had been established, careful records of mold temperature variations were obtained.

Simultaneously, a cooling curve was taken in the casting. Proceeding in this manner, each combination of mold and casting was brought to equilibrium for four or five different operating cycle times. Equilibrium was established on the longest cycle first and then on progressively shorter cycles until a limiting rate of operation was recorded, or until a limiting rate could be determined by a short extrapolation. The molds were cooled only by normal convection, conduction and radiation to the atmosphere.

The complete operating cycle for all of the experimental casting runs consisted of the following distinct phases:

1) The interval between pouring and opening of the mold for removal of the casting.
2) An interval after removal of the casting during which the mold remained open.
3) An interval during which the mold was closed prior to pouring.

The duration of the first interval was equivalent to the time needed for complete solidification of the casting as determined from the eutectic thermal arrest. The balance of the total cycle time was then arbitarily divided equally between the second and third phases of the operating cycle.

MOLD TEMPERATURES AND CASTINGS SOLIDIFICATION TIMES

Experimental data obtained in the foregoing manner consisted of a series of mold temperatures vs. time curves, and a corresponding series of cooling curves for the casting. Typical curves are shown in Fig. 2 for the combination of the 1.0 in. thick mold and 0.5 in. thick casting. Curves are included for four cycle times. The repetitive sequence of mold temperatures shown is typical for systems that have attained a state of dynamic thermal equilibrium.

Such a state is established when the mold temperature rises sufficiently so continuous heat dissipation from the mold balances the intermittent heat input from the casting. The small breaks apparent in the cooling portion of the mold temperature curves are the result of the slight drop in cooling rate coincident with closing the mold.

Cooling curves for the castings are shown just above the mold temperature curves. It is evident that solidification was retarded by the higher mold temperatures which developed when castings were poured with greater frequency. The shortest permissible cycle time, or the maximum permissible rate of operation, was reached when the mold became so hot that almost the entire cycle was needed to complete solidification in the casting. Bar graphs included in the lower portion of Fig. 2 show the lengths of the various portions of the operating cycle.

The mold temperature sequence for different op-

erating rates and for different mold-casting combinations may be compared most readily on the basis of the maximum and minimum temperatures recorded during an operating cycle. To facilitate this comparison, mold temperature data were assembled in curves of the form shown in Fig. 3. Curves are included in this figure for nine mold-casting combinations.

For any particular combination of mold and casting, the two curves which start in the lower right portion of the graph and converge toward the upper left represent the maximum and minimum mold temperatures developed by casting plates at various rates. These temperatures are actually plotted as functions of the total cycle time corresponding to each casting rate. The curve which starts in the lower left corner of each graph and intersects the minimum mold temperature curve at its upper extremity defines the time required to completely solidify the casting for each value of minimum mold temperature.

At the casting rate corresponding to the point of intersection of the minimum mild temperature curve and the solidification time curve, practically the entire cycle is required for solidification of the casting. More rapid rates of casting are not possible, and thus this time value defines the maximum permissible rate of operation.

It is evident from Fig. 3 that mold temperatures, casting solidification times and the maximum permissible speeds of operation are influenced considerably more by variations in casting thickness than by variations in mold thickness.

MOLD DIMENSIONS EFFECTS AT SPECIFIC OPERATING RATES

A number of mechanical operations is generally involved in the production of permanent mold castings. These include pouring the casting, removing and cooling cores, opening the mold, removing castings and reassembling mold parts. Duration of the operating cycle in many cases is determined more by the time required for these mechanical operations than by time needed to solidify the casting. This is particularly true with molds designed for manual operation.

In such cases, the mold designer should have some knowledge of the relationship between mold thickness and operating mold temperature. This is important because mold temperatures influence solidification rates and thus the metallurgical quality of castings. Mold temperatures also affect mold life.

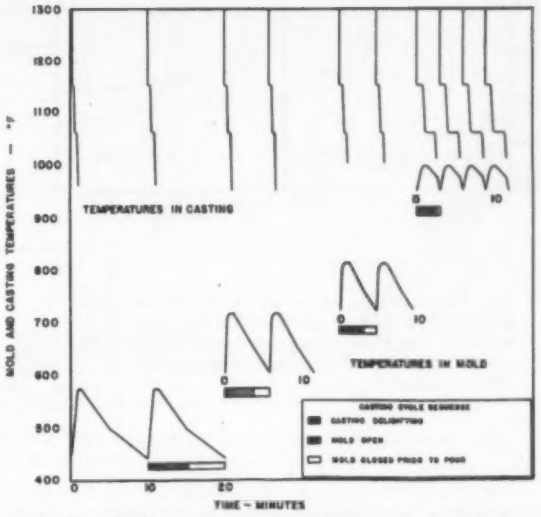


Fig. 2 — Cyclic temperature variations when casting 0.5 in. thick castings in a 1.0 in. thick mold.

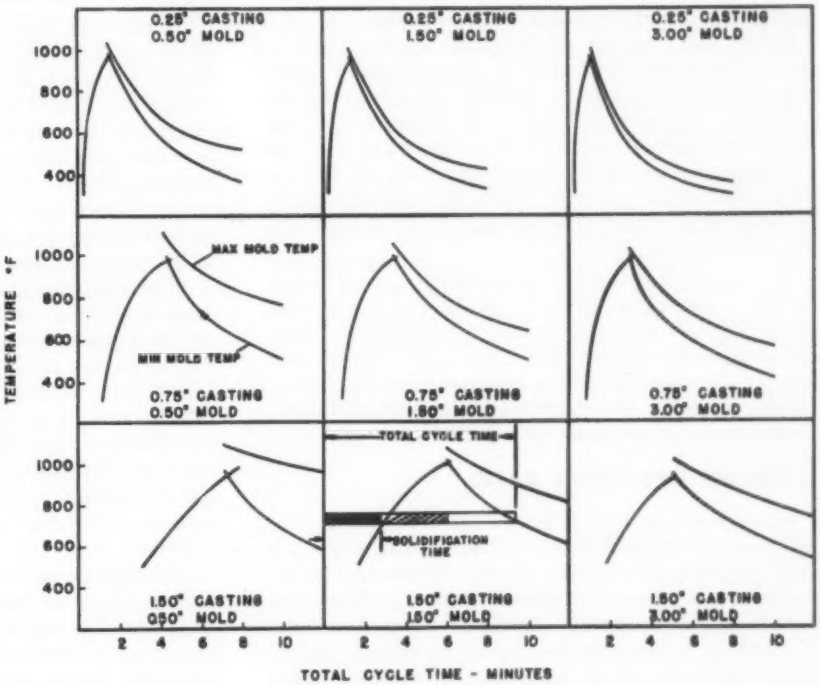


Fig. 3 — Curves showing effect of total cycle time on mold temperatures and casting solidification times. Curve starting in lower left of each graph shows time to solidify casting for any specified minimum mold temperature. Relationships are shown for the nine different mold-casting combinations.

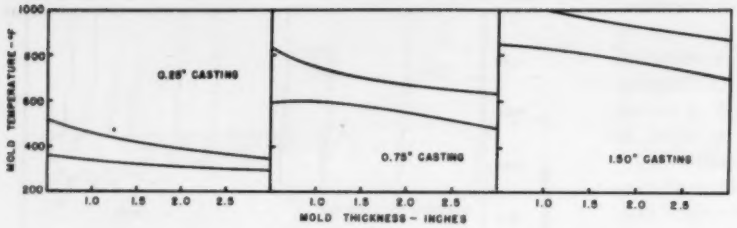


Fig. 4 — Mold thickness effect on maximum and minimum temperatures of molds operated on an 8 min cycle. Relationship is is shown for three values of casting thickness.

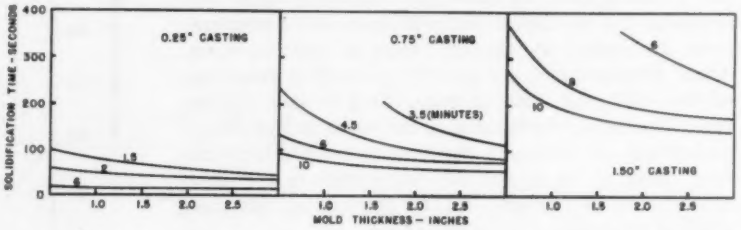


Fig. 5 — Influence of mold thickness on solidification time of castings. Relationship is shown for three casting sections and a number of total cycle times (figures affixed to curves).

The effects of mold section thickness on the maximum and minimum temperatures of molds operated at a specific rate are shown, for three values of casting thickness, in Fig. 4. It is evident that thicker molds generally operate at lower temperatures than thin molds. A change in mold thickness from 0.5 to 3.0 in. may lower the operating temperatures by as much as 250 F (121 C).

The influence of mold thickness on solidification of castings is shown in Fig. 5. This influence, of course, is a consequence of variations in mold temperature. It is apparent that when the casting rate is constant the solidification rate increases with increasing mold thickness. For example, on a 4.5 min cycle, a 0.75 in. thick casting solidifies in 165 sec in a 1 in. mold, compared with 100 sec in a 2 in. mold. This effect is more marked with thicker castings and at the higher production rates. A higher solidification rate is usually desirable because of the finer structure and higher mechanical properties which will be obtained.

While the forgoing relationships appear valid, it should be pointed out that varying the mold thickness in different parts of a single mold is relatively ineffective in providing thermal gradients for feeding. The high thermal conductivity of aluminum alloys generally requires more drastic measures to develop adequate thermal gradients. Such measures can usually be provided by varying the mold coating thickness or by chilling locally.

Because of their greater heat capacity, thick molds require a greater number of casting cycles and take longer to reach operating equilibrium than thin molds. By virtue of the same characteristic, thick molds cool less rapidly when operation is interrupted. This latter feature would be advantageous when short shut-down periods occur in the production foundry.

MAXIMUM OPERATING RATES

Maximum rate considerations are of importance in fully automatic permanent mold operations where the time required for mechanical movements can be reduced to a minimum. It should be kept in mind that data from the present tests are directly applicable only to molds of uniform section cooled by normal dissipation to the atmosphere. Automatically operated molds may be cooled in this manner, or may be equipped with means for accelerated cooling.

It was pointed out previously that the maximum permissible operating rate is realized when the mold becomes so hot that almost the entire casting cycle is needed for solidification of the casting. Limiting rates determined from the intercepts of minimum mold temperature curves with casting solidification curves (Fig. 3) are shown in relation to both mold thickness and casting thickness in the diametric projection of Fig. 6. The figure shows that casting thickness is the most influential factor determining the ultimate casting rate. Mold thickness variations are of some consequence, however, and it will be observed that the increase from 0.5 to 3.0 in. provided an average increase in maximum operating rates of approximately 40 per cent.

MOLD OPERATION WITHIN SPECIFIED LIMITS

At the maximum permissible rate, mold temperatures will be in excess of 950 F (510 C). Since these higher temperatures may accelerate deterioration of the molds, it may be desirable to specify a maximum operating rate which will hold mold temperatures below some arbitrarily selected value. These rates can be determined from the maximum mold temperature vs. cycle time curves of Fig. 3. Production rates with a mold temperature limitation are, of course, considerably lower than the theoretical maximum rates.

Production rates which are possible with an arbitrary limitation on the maximum mold temperature of 800 F are plotted both against mold section and casting section thickness in the diametric projection of Fig. 7. Once again it will be noted that any particular casting may be produced at a faster rate within this temperature limitation by increasing the mold section thickness. Increasing the mold thickness from 0.5 to 3.0 in. permits, depending upon the specific casting section, operating rate increases of from 50 to 100 per cent.

The maximum operating rate may be defined by the requirement that a specific minimum solidification time be assured. This might be desired, for example, to produce a casting of requisite metallurgical structure. At the maximum permissible rate of opera-

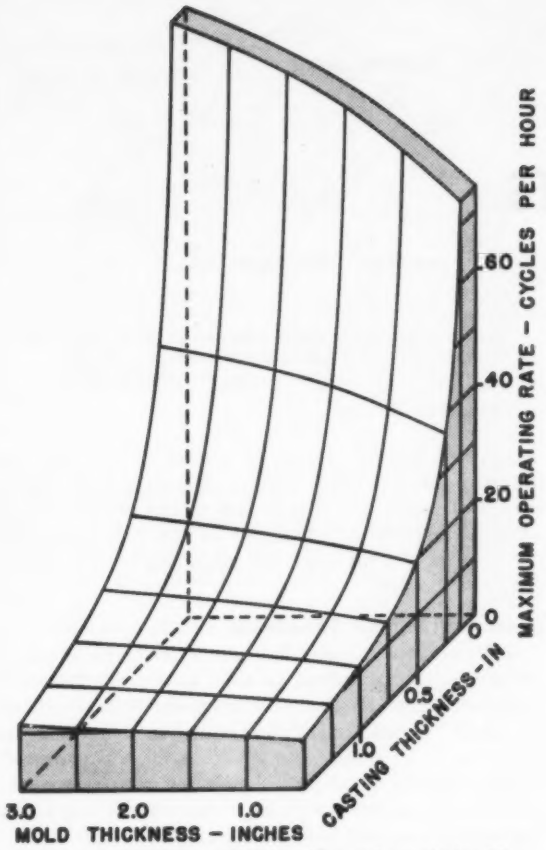


Fig. 6 — Diametric projection illustrating relationship between mold thickness, casting thickness and maximum permissible operating rate. Molds cooled only by normal dissipation.

tion, solidification is slow and may be accelerated only by operating more slowly or changing the conditions of mold cooling. Operating rates necessary to assure specified solidification times also may be determined from the mold temperature and solidification time curves of Fig. 3.

PRODUCTION CASTINGS

Commercial castings are more complex than the simple plates employed in this experimental program. The solidification time for production castings is usually not established by the thickness of the predominant areas of the casting but by the size of bosses, ribs or risers. Nevertheless, the basic principles illustrated by this investigation for simple castings should be applicable to more complicated parts. Probably the major differences in production work arise from use of accelerated cooling with forced air or water.

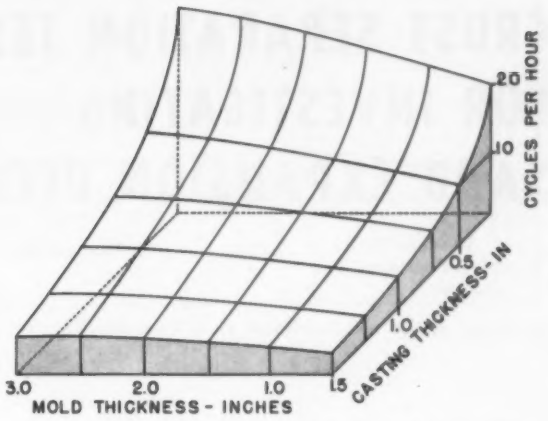


Fig. 7 — Operating rates which limit maximum mold temperature of 800 F.

SUMMARY

When aluminum castings are produced cyclically in permanent molds, mold temperatures, casting solidification times and permissible operating rates are influenced considerably more by the thickness of the casting than by mold thickness. Significant changes in these operating characteristics, however, can be made by changing the mold thickness within practical limits. For a selected production rate, thicker molds operate at lower and more uniform temperatures and provide more rapid casting solidification. For any specified rate of solidification, higher production is possible with thick molds.

Moreover, with thick molds short delays in production cause less disturbance of normal operating conditions. These advantages are in some cases partially offset by the greater difficulty of handling and operating heavy molds, and compromises are sometimes required.

Although the solidification rate of a casting is affected by mold thickness, variations in thickness within a single mold are not particularly effective in controlling the direction of solidification and feeding. This problem must be solved by appropriate gating and risering augmented by control of coating thickness and sometimes by localized heating or cooling.

CRUST SEPARATION TEST FOR INVESTIGATING SAND EXPANSION DEFECTS

By P. W. Goad

ABSTRACT

The development of a new technique for studying expansion defects is described, together with some applications of the technique. It has been shown that expansion failures can occur at relatively low temperatures at which sand expansion is in the range 0.25 — 0.7 per cent, and in the presence of wood flour in excess of 3 per cent. These results indicate that expansion failures can occur even when deformation substantially exceeds expansion.

Moisture content of the sand has been found to be a vital factor in determining the nature of the expansion failure and susceptibility.

INTRODUCTION

A conspicuous gap in past investigations of expansion defects has been the failure to determine sand temperatures at their initiation. It has generally been believed that temperatures in the vicinity of the α-β quartz inversion at 573 C (1063 F) were most favorable because expansion reached its maximum at this point.

This paper describes a technique for investigating the behavior of molds under thermal shock conditions similar to those during casting, and its application to the measurement of sand temperatures at the initiation of expansion defects. A study of the mechanisms of formation of scab and rattail defects, which accompanied the development of the technique, has led to a more complete understanding of the fundamentals involved.

Officially Sponsored Exchange Paper from the Institute of British Foundrymen, Australian Branch (Victoria).

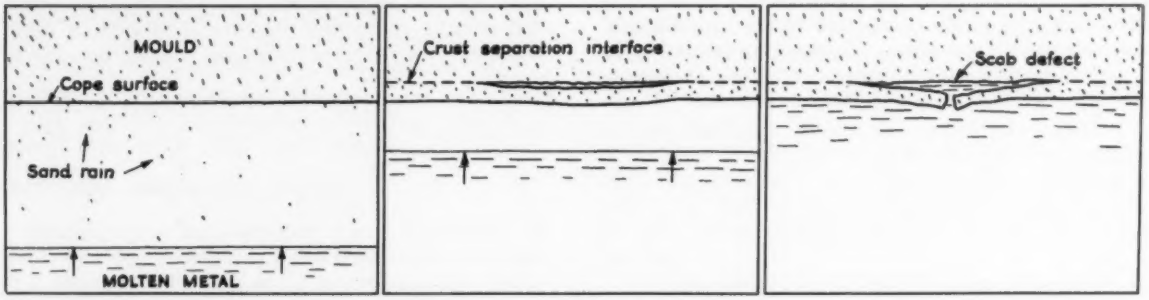
P. W. GOAD is associated with Foundry Sands Section, Chemical Research Laboratories, Commonwealth Scientific and Industrial Research Organization.

Scab and Rattail Formation

Scabs and rattails result from the same basic cause, the separation of a crust of sand under the influence of rapid thermal expansion from the main body of the mold. The defects differ in appearance owing to the manner in which the mold surface is ruptured, which in turn depends on how the crust separates. The formation of a scab at a typical site on a flat cope surface occurs in three stages:

Stage 1. The mold surface is heated rapidly by radiant heat from the molten metal as it rises in the mold, and rapid expansion of the surface sand follows. The first effect of expansion is the expulsion of some individual grains from the surface as grain repacking commences, and a "sand rain" falls[1] (Fig. 1a).

Stage 2. Heat penetrates sufficiently to cause expansion at an appreciable depth (several grain diameters at least). Grain repacking locks the sand into a cohesive crust, and the sand rain ceases. Lateral expansion of the crust proceeds beyond the stage where it can be accommodated by grain repacking, and the crust then separates from the cooler adjoining sand,

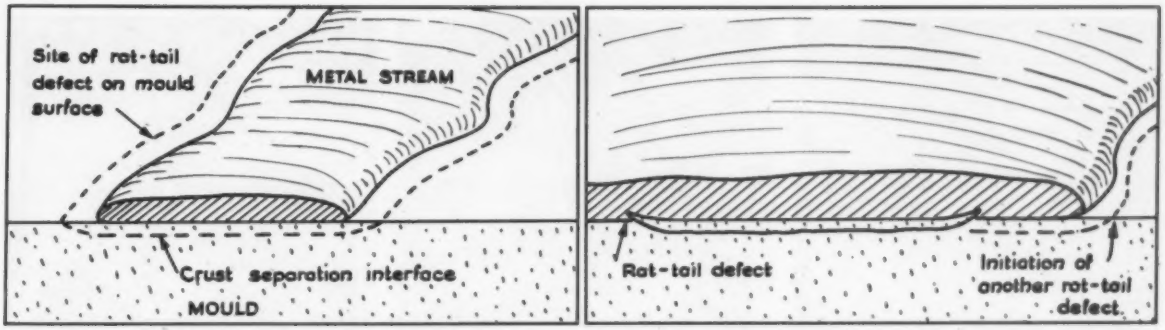


a): Expansion of surface sand causes expulsion of some grains and a "sand rain" falls.

b): Cohesive crust of dried-out sand separates from moist and adjacent sand.

c): Metal flows through fractured crust to form scab defect.

Fig. 1 — Stages in the formation of a scab at a cope surface.



a): Crust of dried out sand forms under metal stream, and as it expands initiates mold surface cracks at sides of metal stream.

b): Expansion of crust continues when molten metal covers mold face.

Fig. 2 — Formation of a rattail at drag surface.

and with the assistance of gravity bulges downward toward the rising metal (Fig. 1b).

Stage 3. The separated crust breaks when or just befor the metal touches it, and the metal flows through the break and into the space behind the crust (Fig. 1c). If the crust breaks and the broken parts are displaced but the metal does not penetrate behind, the resulting casting defect is usually called a buckle, but it is in fact a partly formed scab. If part or all of the separated crust falls onto the metal and is carried away, the defect becomes a "blind" or "dummy" scab.

While the typical site of a scab is a cope surface receiving radiant heat from the metal as it fills the mold, rattails (except in thin section castings) occur only at drag surfaces. Their formation depends on a mechanism which was originally described by Pettersson.[2] In the initial stages of casting, molten metal flows over drag surfaces either in separate streams or with an irregularly advancing front. Underneath the metal a surface sand layer is rapidly heated, and accompanying lateral expansion causes it to separate as a cohesive crust from the underlying sand.

Crack Formation

Directly underneath the metal stream the crust is of uniform thickness, but beyond the metal boundary the crust separation interface slopes up to terminate at the mold surface. At this location a crack is formed (Fig. 2a). The crust continues to expand after the molten metal has covered the mold face (Fig. 2b), and the cracking is intensified either until expansion ceases or the metal solidifies. In thin section castings the metal stream may touch or closely approach the cope surface, and a rattail may then be formed there in an identical manner. The position of a rattail defect is invariably related to the position of the metal boundary at some stage in the covering of the surface (Fig. 3).

Rattails may have the appearance of furrows, steps or even of scab-like fins, if the metal penetrates down the crust separation interface (Fig. 4). Defects which are best described as scabs, but which share some of the characteristics of rattails, may be formed where there is an exposed edge in the mold (corresponding to a re-entrant angle in the casting, e.g., in the AFS 8-J test casting[3]), which allows a separated crust to expand freely into the mold cavity.

Moisture Effect

When crust separation occurs in a green sand mold, the separation interface is the boundary between a hot dried-out surface layer and moist underlying sand.[4,5] Separation cannot be regarded simply as a mechanical failure in a uniform material loaded to its limit, because the expansion forces are concentrated at a well-defined location—the junction between the relatively strong dry crust and the far weaker moist sand in the main body of the mold.

Conditions at the interface may be further influenced by the formation of a region of high moisture content behind the dried out surface layer, caused by the condensation of moisture evaporated from the surface.[6] Temperature rise in the high moisture region is delayed by evaporation while the surface temperature increases rapidly. This may lead to the formation of a temperature "step" across the interface.

Crust Separation Test

Scab defects can be studied by direct observation, since it is a simple matter to produce scab-type failures in a sand face by suddenly exposing it to a source of intense radiant heat. However, in determining initiation temperatures this is not a satisfactory approach because there is unlikely to be a definite indication of the precise moment of crust separation, and it is possible for a separated crust to reach maximum expansion without the occurrence of a surface rupture.

On the other hand, when the rattail mechanism operates, crust separation and surface rupture occur almost simultaneously, as even a small expansion of the separated crust must break the mold surface, and there is, therefore, a visible indication of the initiation of the failure. This characteristic of the rattail mechanism has been utilized in the "Crust Separation Test."

This test simulates the effect of metal streams flowing over a mold face and producing rattail-type failures in the sand surface. The specimen, which consists of a narrow strip of a flat sand face, is suddenly exposed to a source of intense radiant heat. The center of the strip is protected from direct heat by a shield placed a small distance above the sand face. The directly-heated areas behave as if they were cov-

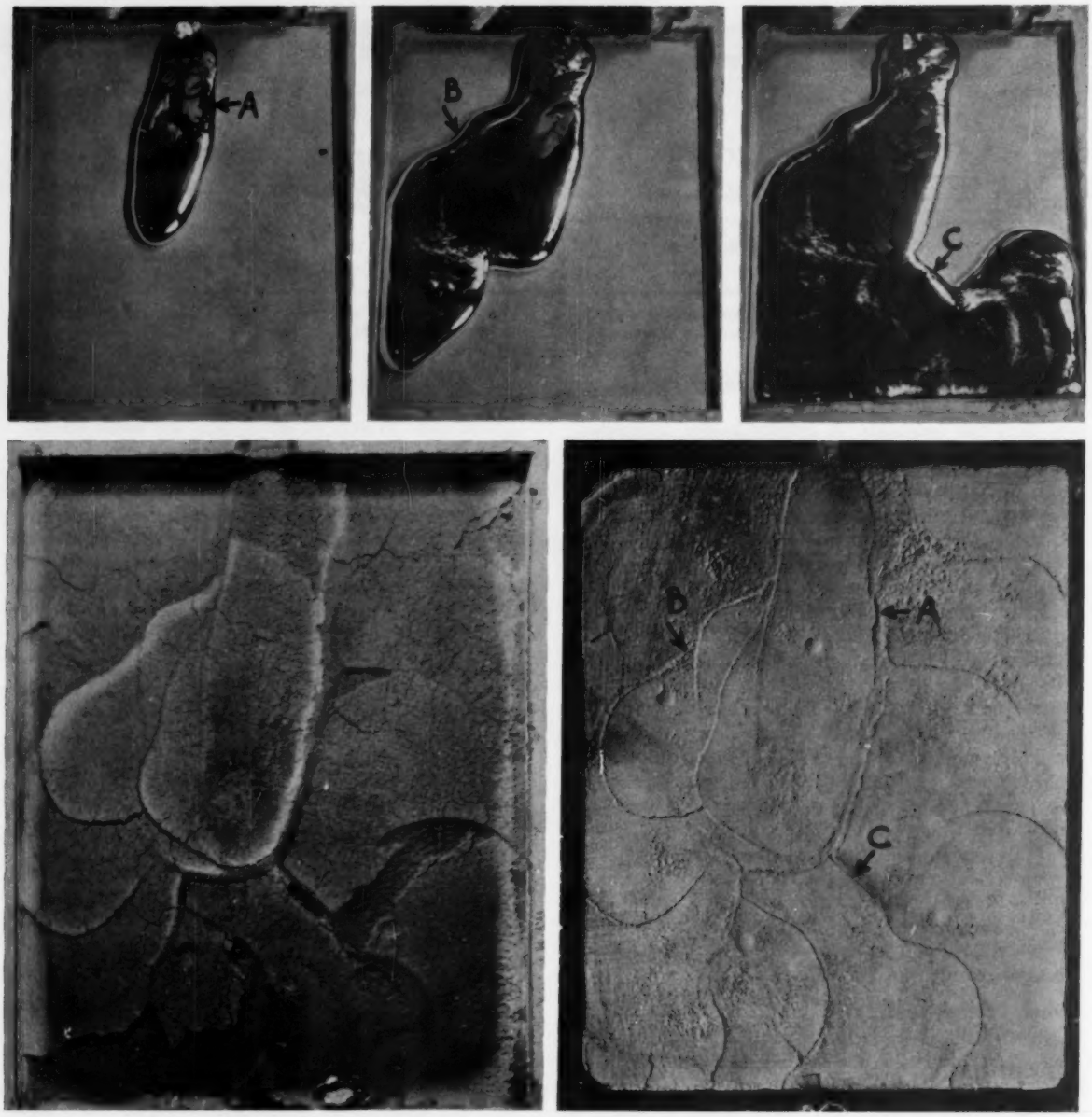


Fig. 3 — Relation between metal flow pattern and rattails. The upper row shows three stages in the pouring of a plate in an open-top mold. The position of the metal boundary at each stage (e.g., locations A, B, C), can be related to a rattail defect in the casting (lower right). The mold, after removal of the casting (lower left) shows typical crust separation. (The photograph of the casting has been reversed in printing to aid comparison with the other pictures.)

ered by broad metal streams, and the sand protected by the shield corresponds to the sand lying alongside the stable boundary of a metal stream.

Consideration of the factors which might be involved in the operation of the metal stream mechanism suggested that surface failure would probably be accelerated if:

1) Two metal streams were so situated that their crust separation interfaces met at the mold face.
2) These streams were wide so that lateral expansion of the crusts beneath them was considerable.
3) Stress concentrators were present at the failure line.

Obviously, these conditions seldom all apply in practice, but they can be easily produced in the test. By adjusting the width and height of the shield, the crust separation interfaces on either side of the shield can be made to meet at the sand surface along the transverse center line of the sand strip (Fig. 5). The length of the strip is limited mainly to the type of heat source used, but, in the present form of the test, metal streams 4½-in. wide are simulated. Stress concentrators at the failure line are provided by notches on each side of the strip. The general arrangement of the test apparatus is shown in Fig. 6.

The test specimen is rapidly slid or swung under

Fig. 4 — Bronze plate casting, showing scab-like defect in drag surface caused by penetration of metal down crust separation interface.

the heat source (this takes less than 1 sec), and the strip surface is observed until either a failure occurs or until the surface temperature in the directly-heated areas is above about 700 C (1292 F). The sand surface under the shield is illuminated by a powerful light beam projected at a low angle. Small disturbances of the sand surface in the early stages of crust separation, which would be invisible with normal illumination, are plainly silhouetted. Usually, the failure can be seen to flick across from notch to notch in a thin dark line (Fig. 7).

The appearance of typical failures in moist synthetic sands is shown in Fig. 8. In Fig. 9 rattail-type failures produced by metal streams are compared with that produced in a crust separation test specimen.

Test Uses

Any of three criteria might be used in evaluating the susceptibility of a sand to expansion defects.

1) Crust temperature at initiation of separation failure.
2) Amount of standardized additive (e.g., wood flour) required to prevent separation failure.
3) Time interval to separation failure.

As will be shown later the usefulness of (1) appears more limited than (2) and (3).

Sand Specimen

A flat sand face measuring 10 x 5 in. is prepared by ramming up a 10 x 5 x 2 in. box. The face is cut away to a depth of $\frac{3}{8}$-in., leaving a central strip $2\frac{1}{2}$-in. wide extending from end to end of the box. Notches $\frac{1}{4}$-in. deep are cut on both sides of the strip at its center. Over the notches the heat shield, which is made of 0.1-in. steel sheet, is placed with its top surface parallel to and $\frac{5}{16}$-in. from the sand face. The width of the shield is $1\frac{1}{16}$-in., but this is not a highly critical dimension. The test specimen is illustrated in Fig. 10.

Heating Method

As a readily controllable source of heat is neces-

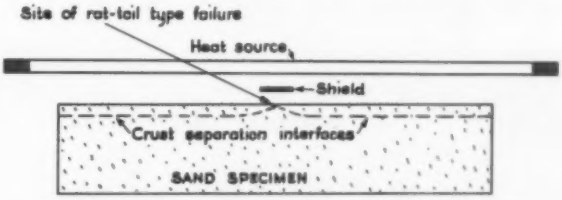


Fig. 5 — Diagram showing location of crust separation interfaces in the crust separation test.

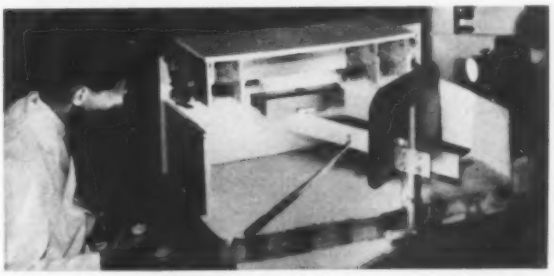


Fig. 6 — General arrangement of crust separation test apparatus.

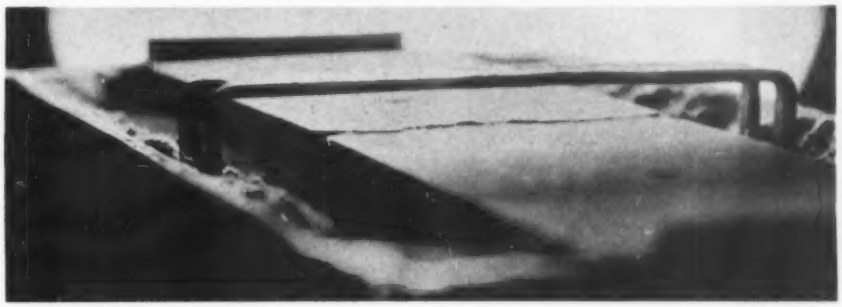


Fig. 7 — Crust separation failure soon after initiation, as seen by operator.

sary if tests are to be reproducible, and as it is essential to observe the sand surface throughout the test, it is not practicable to use molten metal. Wire wound resistance elements operating at approximately 900 C (1652 F), were used in early work, but a more intense heat proved desirable. Two 1-in. diameter silicon carbide rods set at 1⅞-in. centers, operating at 1300-1400 C (2372-2552 F) have proved satisfactory.

Casting Tests Correlation

Experiments were made to compare the susceptibility to rattails, as indicated by the crust separation test, with the formation of these defects on a test casting. Sand mixes are based on a silica sand of AFS fineness 100 and contained 2, 4 and 6 per cent western bentonite, and 2.4 per cent moisture. Wood flour (soft wood, -85 mesh) was added in steps of 0.25 per cent until the sand mix showed no tendency to failure in the crust separation test. The mix with the "end-point" addition of wood flour was used as a facing for molds in which the test castings were poured. End-point wood flour additions for the three sands were:

Bentonite in sand mix, %	Wood flour required to prevent failure, %
2	3.5
4	3.5
6	3.0

Casting conditions were designed to favor the initiation and maximum development of a large number of failures. Aluminum, chosen because of its low density and intermittent, sluggish-type of flow, was poured slowly at a temperature well above its freezing point into an open top plate mold. Details of the casting procedure were as follows:

Mold: 11 x 9 x ½ in., major face horizontal, open top, single gate centrally placed on one of the short sides; mold hardness approx. 75.
Metal: Commercially pure aluminum.
Pouring conditions: Temperature, 800 C (1472 F), mold filled in 30 sec (pouring rate about one-sixth of normal).

The appearance of castings made in sand mixes with and without the end-point wood flour additions, are shown in Fig. 11. The wood flour additions were obviously insufficient to eliminate the defects completely. However, when casting conditions were altered to bring them more into line with normal foundry practice (viz., the mold was poured through two gates, and filled in 5 sec) the defects were eliminated. The castings were still imperfect, particularly near the gates, because the extreme friability of the sands rendered the molds susceptible to erosion with the faster pouring rate (Fig. 12).

In selecting a casting test as a standard of comparison it is difficult to decide how severe the conditions should be. However, it is clear that the end-point additions of wood flour necessary to inhibit rupture of the surface in the crust separation test are greater than the amounts usually considered necessary or desirable in foundry practice. This fact suggests that the test is more exacting than normal foundry conditions.

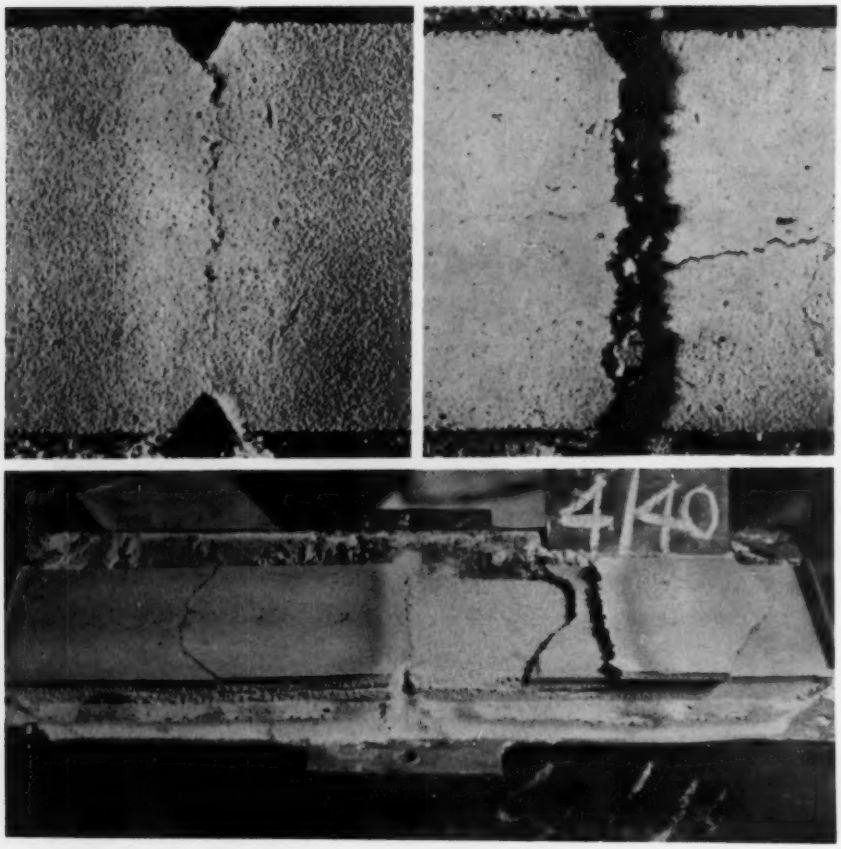


Fig. 8 — Typical rattail-type failures produced in crust separation test. Top left: Failure immediate after initiation. Top right: Failure after completion of sand expansion. Bottom: Appearance of test specimen after failure. Part of separated crust has been displaced to show its cohesive nature. Transverse cracking of crust at left occurred on cooling of the specimen.

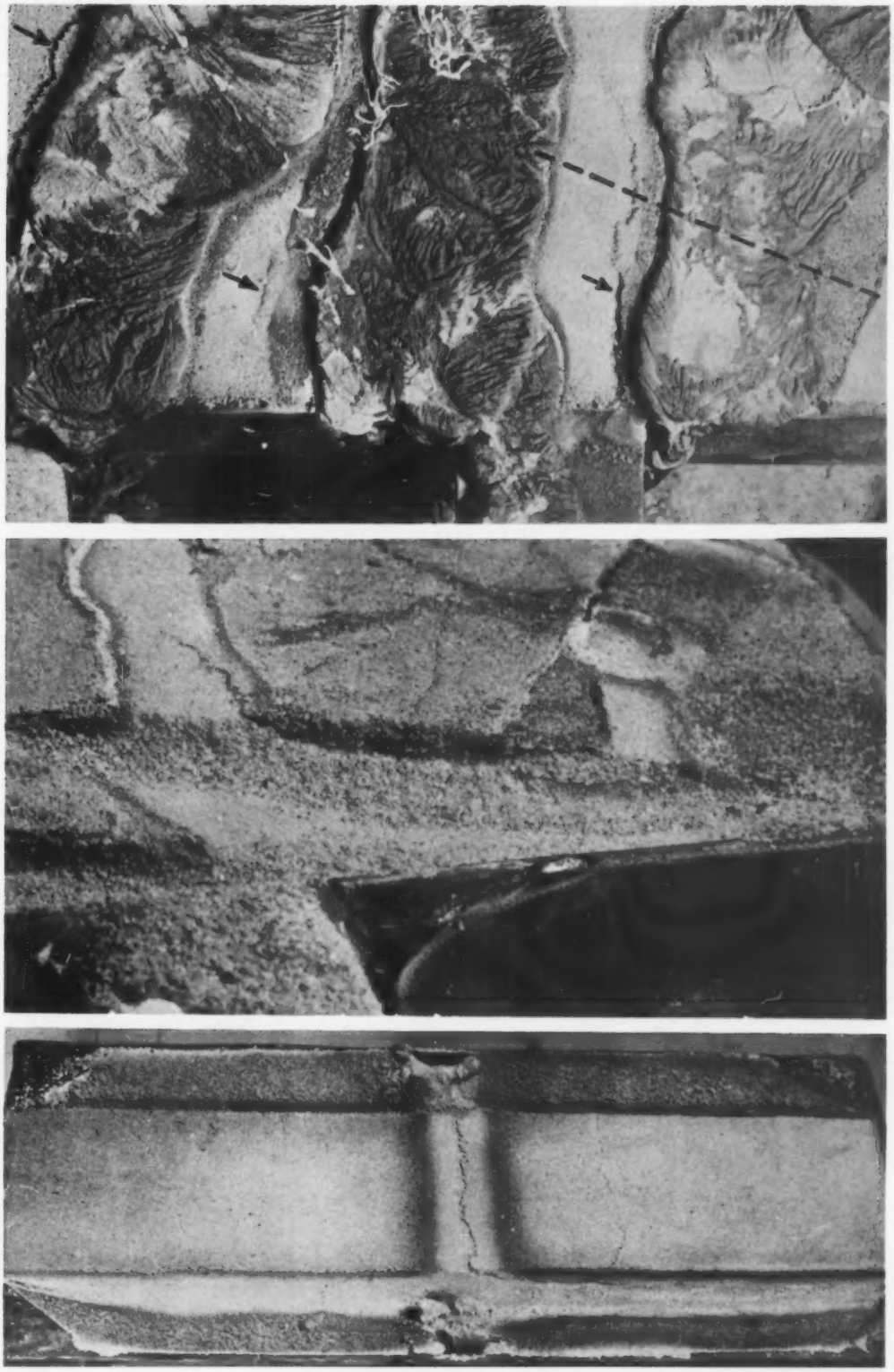


Fig. 9 — Comparison of crust separation failures produced by metal streams and in crust separation test. Top: Surface cracking (arrowed) produced alongside streams of molten bronze allowed to flow continuously over a sloping mold face. Photograph taken after streams solidified. Center: Mold face after removal of solidified metal and sectioning (at location shown by dotted lines in top photograph), showing crust separation. Bottom: Failure in crust separation test specimen, showing surface cracking in shielded area, and separated crust. This specimen was not notched.

It is of interest to note here the small effect of considerable variation in bentonite content on the end-point wood flour additions.

As yet, no work has been done to correlate results from the crust separation test with the occurrence of scab defects in test castings. However, it seems unlikely that a sand could show scabbing tendencies without being susceptible to rattails, as conditions pertaining when rattails are formed are far more favorable for crust separation and rupture of the mold surface. In this connection, the following aspects of rattail and scab-type failures are important:

1) When the rattail mechanism operates, there is little opportunity for expansion to be accommodated by grain repacking, as resistance to expansion is small. The crust merely slides up the sloping portion of the crust separation interface. At the typical site of a scab defect, the crust separation interface does not meet the surface and, in the early stages at least, more resistance to expansion is likely. Also, crust separation does not immediately cause surface rupture.
2) The degree of heat shock is greater when rattails are formed as the metal is in contact with the sand.
3) Molten metal lying on the drag surface of a mold face assists in the formation of a thin but cohesive crust, since surface grains are not pushed out of position as readily as from a cope surface. Observations by the author have indicated that a crust capable of causing a severe rattail may be only two or three sand grains in thickness.

CRUST SEPARATION TEST APPLICATION

Sand Temperature at Initiation of Expansion Defects

Since the actual site of a rattail-type failure in a green sand mold is part of the crust separation interface, and its temperature when failure is initiated is, therefore, probably close to 100 C (212 F) [the interface being the boundary between the hot dried out surface layer, and the moist underlying sand], measurement of its temperature serves no useful purpose. However, measurement of the maximum temperature of the crust at the moment of separation a) provides a measure of the upper temperature involved in crust separation, and, therefore, in expansion defects, and b) can be used in determining the expansion necessary to cause separation.

The temperature of the crust rises steeply from 100 C (212 F) at the interface to a maximum at the mold surface. Knowing the surface temperature, an

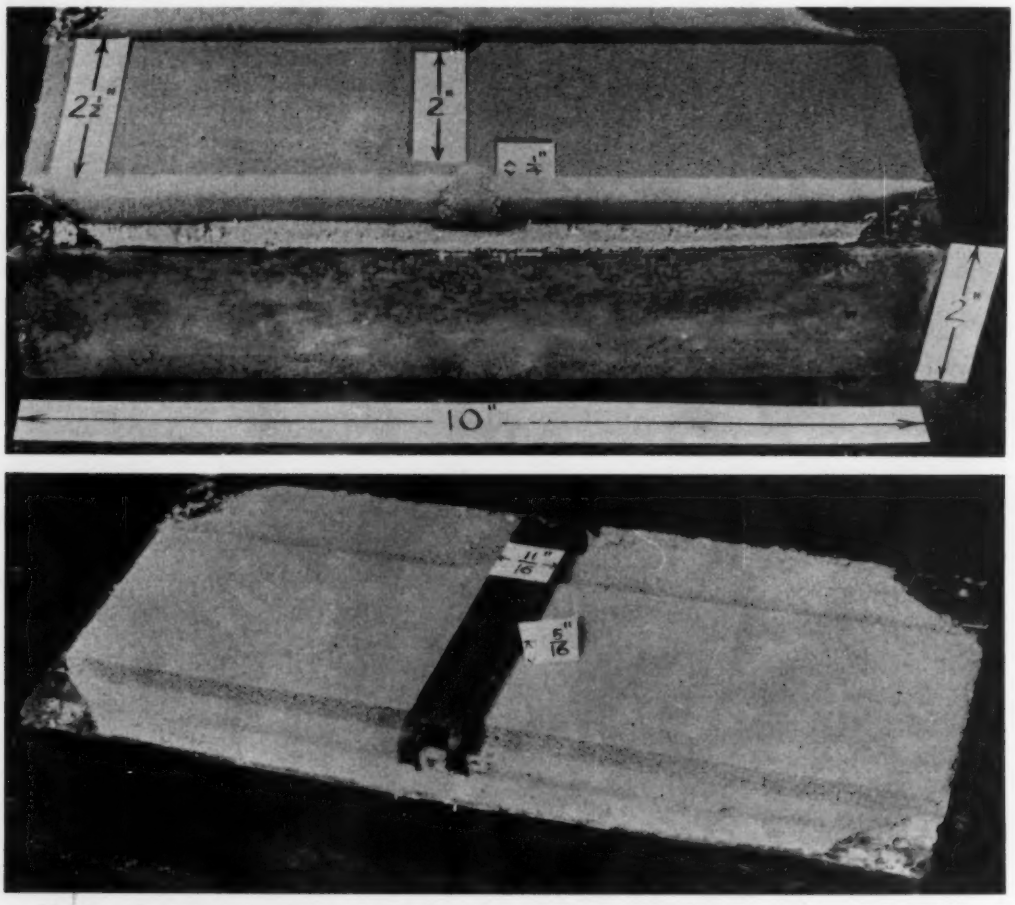


Fig. 10 — Crust separation test specimen. Top: After cutting a strip and notching. Lower: With shield in position. Projecting strips are placed at the ends of the specimen (Fig. 7) if the sand crusts tend to expand over the top of the box.

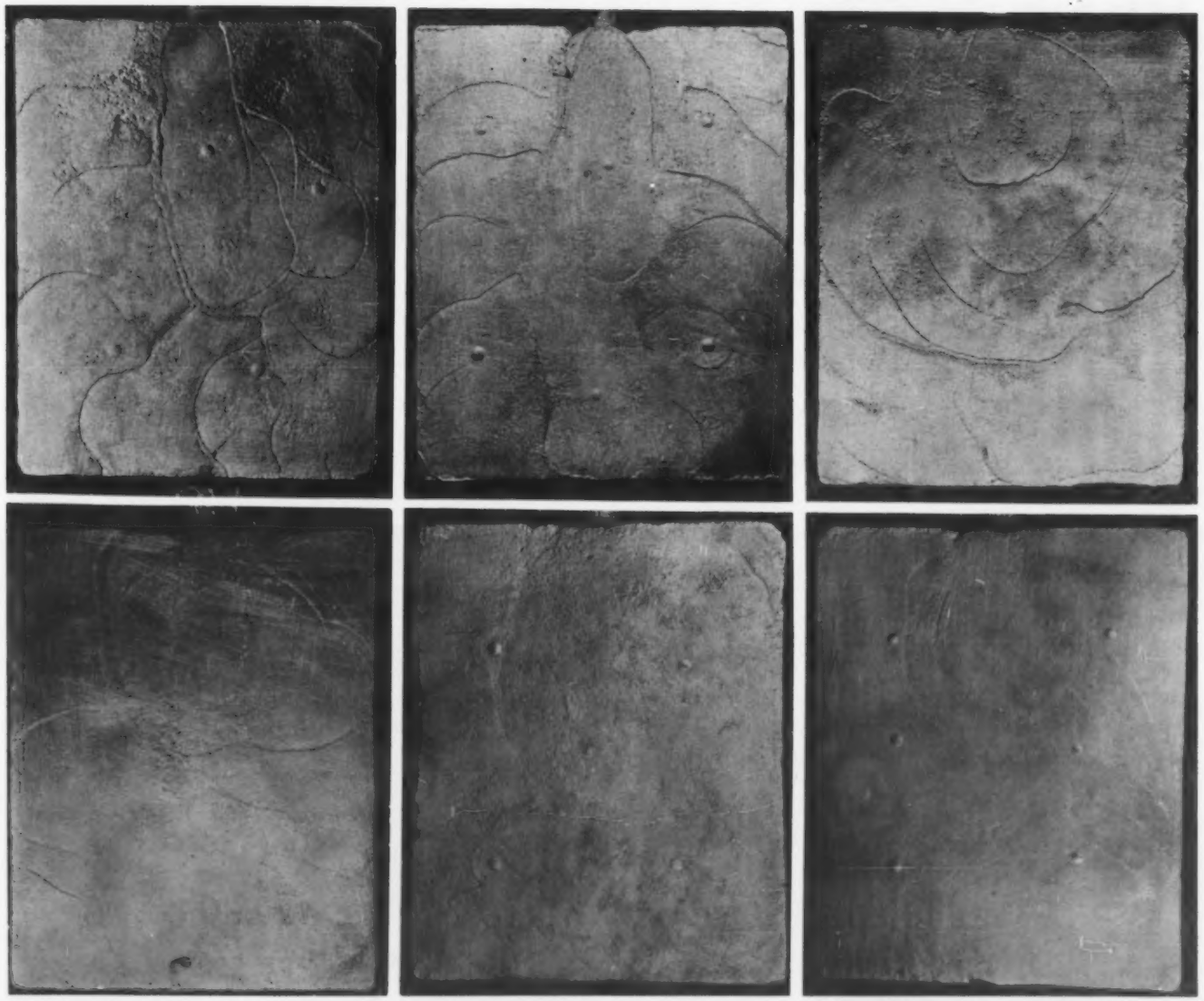


Fig. 11 — Drag surface of plate castings made in green synthetic sand showing effect of "end-point" additions of wood flour. Left to right: 2, 4 and 6 per cent western bentonite. Top: No wood flour. Severe rattailing. Bottom: "End-point" additions of wood flour (3.5 per cent, 3.5 per cent and 3.0 per cent, respectively). Slight rattailing.

adequate estimate can be made of temperature conditions within the crust. It is to be expected that measurements can only be made with a low degree of accuracy, as rate of temperature rise at the specimen surface when the failure is observed is of the order of 30-50 C (86-122 F) per sec, and there can be no certainty that the temperature measuring device is exactly at the same temperature as the surrounding sand grains.

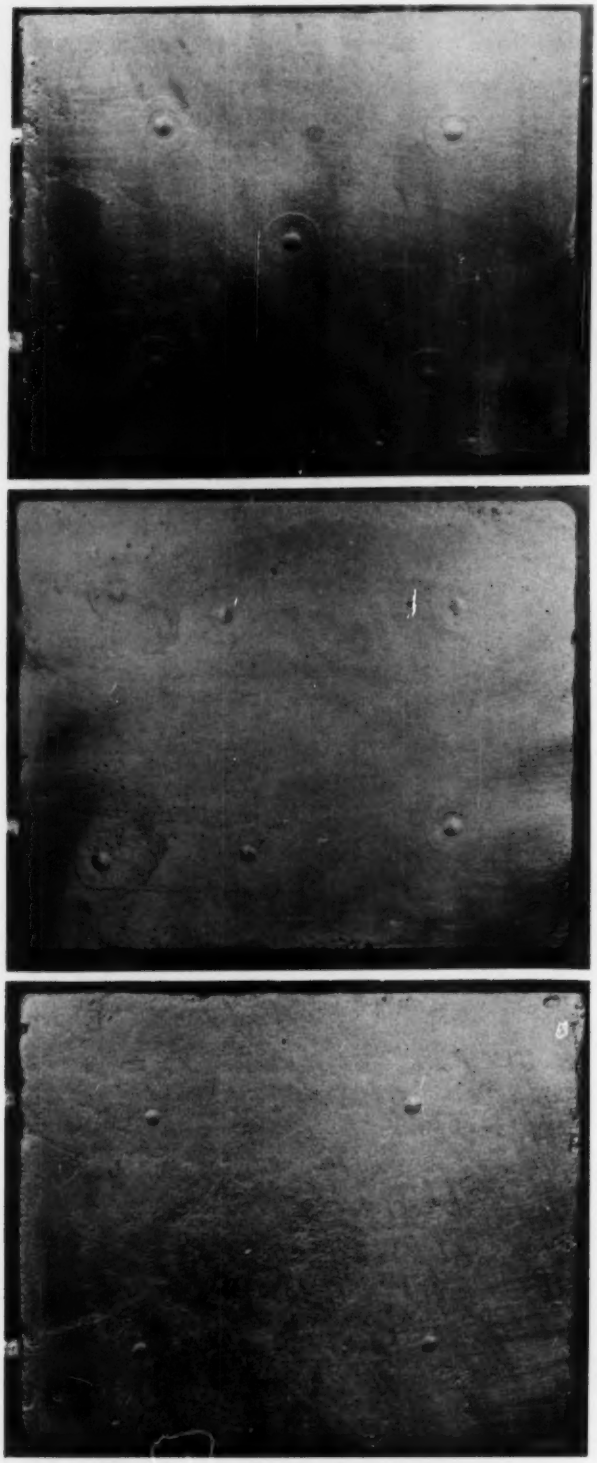


Fig. 12 — Drag surface of Casting made in green synthetic sands containing "end-point" addition of wood flour, and cast at fast pouring rate through two gates (Top of casting is at left in photo). Top to bottom: Sand contained 2, 4 and 6 per cent western bentonite.

However, even an accuracy of ±50 C (122 F), which should be achieved without great refinement of technique, yields a useful result. Because of the equipment, time and experimental care necessary for measurement of crust temperatures, this approach should find application in research rather than in routine testing.

Fine thermocouple wire (0.010 in. diameter or less), and a fast response electronic recorder are used. The coupled wires are embedded in the specimen in a directly heated zone. The welded junction, which is made as small as possible, is placed with its top surface level with the sand surface and slightly exposed, and is packed tightly around with sand grains, which should remain undisturbed throughout the test. The recorder trace is interrupted when the failure is first observed.

Results from the limited amount of work performed to date are shown in the Table.

Temperatures chosen for publication in the Table were those considered likely to err on the high rather than the low side. Much lower temperatures, which suggest that crust separation can occur in natural and synthetic sands when maximum crust temperatures are in the vicinity of 200 C (392 F), have been recorded, but further work will be necessary before this claim can be made with confidence. Duplicate determinations have not been in close agreement, but this is felt to be caused more by experimental error than by variation in the sands behavior.

Conclusions

Conclusions which may be drawn are:

1) Expansion at temperatures between 100 C (212 F) and the quartz inversion at 573 C (1063 F) can initiate crust separation failures.
2) At the initiation of the failure, the temperature of the bulk of the sand in the separating crust may

TABLE — MOLDING SAND TEMPERATURE AT INITIATION OF EXPANSION FAILURE IN CRUST SEPARATION TEST SPECIMEN

Molding Sand	Max. Sand Temp. When Crust Separation Failure Observed, C (F)	Approx. Expansion of Molding Sand at Temp. of Crust Separation Failure,* %
Dandenong natural sand		
AFS fineness—120	400 (752)	0.5
Clay substance—15%	480 (896)	0.7
Moisture—6%		
Synthetic Sand A		
AFS fineness—100	270 (518)	0.25
Western bentonite—2%	380 (716)	0.45
Moisture—2.4%		
Synthetic Sand B		
AFS fineness—100	345 (653)	0.35
Western bentonite—4%	410 (770)	0.5
Moisture—2.4%		

*From data of Parkes and Godding.[7]

be closer to 100 C (212 F) than 573 C (1063 F).

3) Regarding susceptibility to crust separation failure, there appears to be little significance in an expansion deformation relationship. The Table also contains an estimate[7] of the sand expansions at the maximum temperatures of crust separation. These are relatively small (0.25-0.7 per cent), and corresponding deformation values of the sands would be unlikely to fall below these expansions at any temperature. In comparing the values, it should be remembered that expansion of the bulk of the sand in the crust is considerably lower than that occurring at the surface.

Additive Amount Required to Prevent Failure

The amount of a standardized additive to prevent failure (end-point addition) is readily determined, and there is little possibility of experimental error. However, as the amount of the addition is likely to be so large as to be impracticable for foundry use (see final discussion), the test cannot be used in a straight forward manner to estimate the amount of an additive needed to ensure freedom from expansion defects under production conditions. Rather, it is a means of comparing one sand with another, and a guide to the effectiveness of different additives and the influence of sand variables.

An example of the use of the end-point addition criterion is to be found in the description, given earlier, of work to correlate results from crust separation tests and casting tests. It was found there that differences in the end-point additions for synthetic sands containing 2, 4 and 6 per cent western bentonite were only slight, and this indicates that in practice these sands would show a similar susceptibility to rattailing. The results of the casting tests support that conclusion.

The end-point addition criterion has also been used to show the influence of moisture content on susceptibility to crust separation failure (Fig. 18).

Time Interval to Failure

Wood Flour and Other Additions Effect. Time interval to failure is directly related to temperature of the sand crust, and measurements are far more easily made and less subject to experimental error than temperature measurement. Accurate standardization of heating rate is not necessary if results are expressed in terms of the time interval to failure of a standard specimen of high susceptibility. The only additional equipment required is a stop watch.

An example of the effect on time interval to failure of progressive additions of wood flour to a synthetic sand containing 6 per cent western bentonite and 2.4 per cent moisture, is shown in Fig. 13. The curve shows the time interval to be a function of wood flour content. It appears probable that if such a curve were determined for a system sand, it could be used in the routine checking of wood flour contents. If a number of additives are used in the sand, their combined effect will be reflected in the time interval to failure. If this value is maintained at a constant level, this should ensure consistency in those sand properties affecting susceptibility to expansion defects.

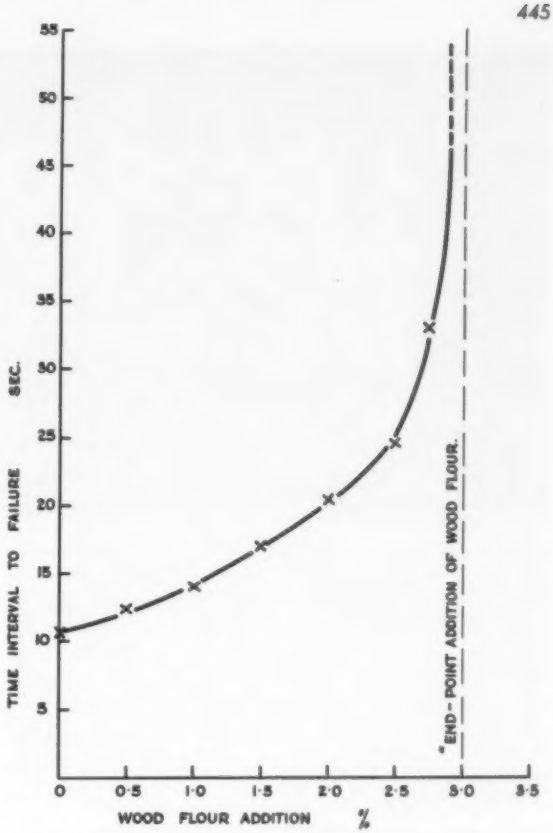


Fig. 13 — Effect of wood flour additions on time interval to failure in crust separation test. Tests performed on synthetic sand (fineness 100) containing 6 per cent bentonite and 2.4 per cent moisture.

Moisture Content Effect on Mold Behavior Under Thermal Shock. Moisture content of the sand is frequently disregarded in investigations of expansion defects, but great importance has been attached to this by Continental workers.[8,9] Pettersson, for example, considered that below about 0.4 per cent moisture, molds were probably not subject to scabbing. Some experiments on the effect of moisture content on susceptibility to crust separation failures were carried out by the author using both the crust separation test and the casting test described above (single gate, slow pouring rate). The synthetic sands containing 2, 4 and 6 per cent bentonite, which were used in the correlation tests, were again employed in this work. The sands were rammed to a mold hardness of approximately 75.

Behavior of Completely Dry Sands. Crust separation test specimens and plate molds were dried by heating for 4 hr at 150 C (302 F), and cooled and stored until required in sealed bins containing silica gel.

In the crust separation test, the dry sand showed behavior quite distinct from that of green sand. The cohesive crusts of uniform thickness in the directly heated areas, and the single crack between the notches in the shielded area characteristic of green sand, were not produced. Instead, failure of the specimen was by a random flaking over the entire surface (Fig. 14).

The appearance of the drag surface of plates cast

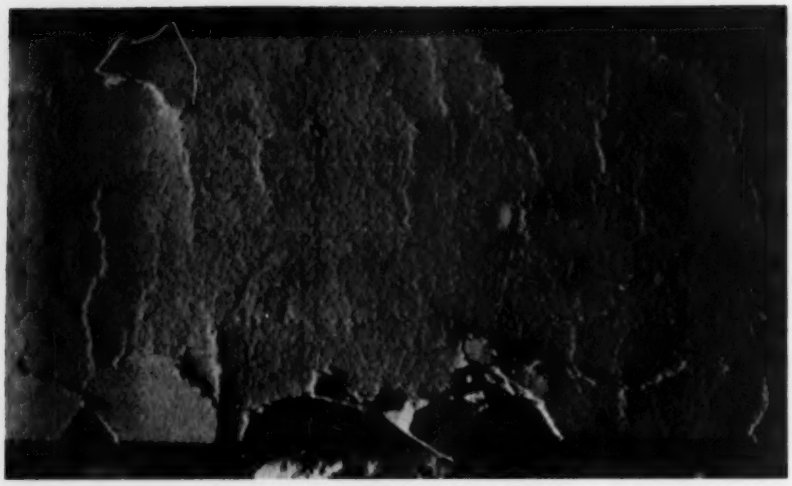


Fig. 14 — Appearance of completely dry sand specimen after testing, showing random flaking.

in the dry molds is shown in Fig. 15. The defects exhibited were probably best described as crazed buckles. Unlike rattails, these defects were not oriented with respect to the metal flow pattern, but were the result of random cracking of the mold surface under the molten metal (Fig. 16). Examination of the mold after removal of the solidified castings showed that failure of the surface was by flaking in a manner similar to that shown by the crust separation test specimens.

Determinations of time interval to failure in the crust separation test indicated that dry sand containing no wood flour or other additive had only a slightly greater resistance to expansion failures than green sand. However, results of work which is now proceeding suggest that the amount of additive required to inhibit expansion failures in a completely dry sand may be much less than that required when the sand contains sufficient moisture to impart normal moldability.

Absorption of Moisture from Atmosphere After Drying. Crust separation test specimens and open-top plate molds were dried by heating at 150 C (302 F), then allowed to cool and stand overnight exposed to the normal laboratory atmosphere.

Behavior of the sands on testing was in all respects similar to that of the sand in the green condition. An example of the extent of rattailing in the casting test is given in Fig. 17. This work showed that it was possible for sufficient moisture to be absorbed from the atmosphere during the cooling and storing of a dried mold to cause the behavior characteristic of a green sand. A similar conclusion was reached by Pettersson.

Moisture Content Effect on Wood Flour Required to Inhibit Rattail-Type Failure in Green Sand. It had been noted during the work on correlation of results from the crust separation test and casting tests, that if moisture content of a sand containing the end-point amount of wood flour were increased, then the sand again became subject to rattailing.

Crust separation tests were made to determine end-point wood flour additions with increasing moisture content, and the results are shown in Fig. 18.

DISCUSSION AND CONCLUSIONS

The results of the crust separation test, which show that the expansion required to cause mold failures is small, do not support the widely held belief that expansion must exceed deformation for the sand to be susceptible to expansion defects.[10,11,12] This idea is also not supported by the results showing that rattailing can occur in synthetic sands containing more than 3 per cent wood flour, the deformation values of which should be high.

Doubt as to the significance of deformation (that is, amount of which the sand can deform under a compressive load, without loss of cohesion) arises when the mechanism of crust separation is considered. Unless resistance is encountered, molding sands expand freely, and if there is free expansion the deformation of the sand is of little account.

When a crust forms under a metal stream, resistance to expansion cannot be great as the crust is able to slide up the sloping portion of the separation interface. Similarly, there can be little effective resistance to expansion when a crust, which may be only ⅛-in. thick, forms over a large area of the cope surface, and the combined effect of gravity and its own expansion is acting to bow it downwards.

The significant factors appear to be the lateral expansion force exerted by the crust and the sand strength at the site of separation interface. Crust separation occurs when the former exceeds the latter. Sand behavior in the crust separation test indicates that failure occurs suddenly after a period of heating, which means that there is some build-up of resistance to expansion. Measurement of the expansion force at the temperature of separation (as could be done with the AFS "Restraining Load Test" apparatus) gives the limiting value of the sand strength at the interface. This value is of considerable theoretical interest.

One of the most important results of this work was to show the effect of moisture. While in moist sands expansion failures occurred by separation of a cohesive crust (the cause of scab and rattail casting defects), in the complete absence of moisture failure occurred by random flaking (the cause of a crazed buckle-type of casting defect). With sands having a

high susceptibility to crust separation in the moist state, e.g., synthetic sands containing no additive such as wood flour, rattailing occurred regardless of variation in moisture content, providing a low minimum moisture content was exceeded.

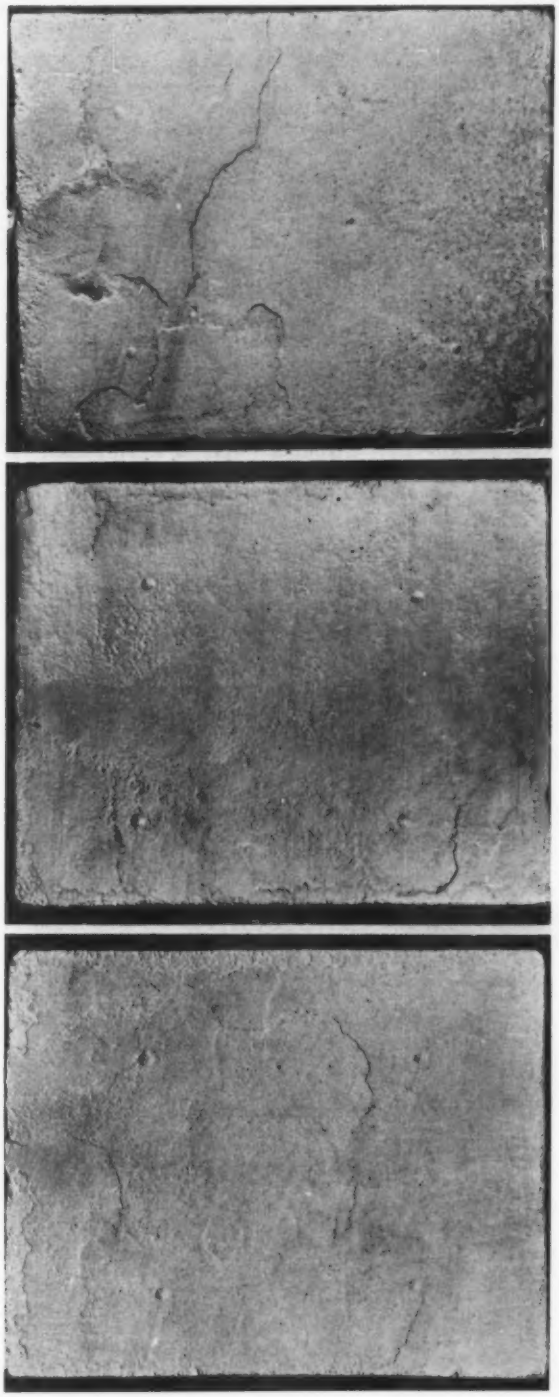


Fig. 15 — Drag surface of casting made in complete dry synthetic sands (Top of castings is at left of photo). Top to Bottom: Sands contained 6, 4 and 2 per cent western bentonite. The castings all show crazed buckle defects, caused by mold failures, similar to those shown in Fig. 14.

Sufficient moisture could be absorbed from the atmosphere on cooling and standing, after drying to render a mold as readily susceptible to rattails as a green sand mold. However, with sands containing an

Fig. 16 — Appearance of completely dry mold after removal of solidified casting, showing random flaking type of failure. The metal flow pattern is indicated by the light colored streaks. The casting made in this mold is shown in Fig. 15 (top) (The photograph of the mold was reversed in printing to aid comparison of mold and casting surfaces).

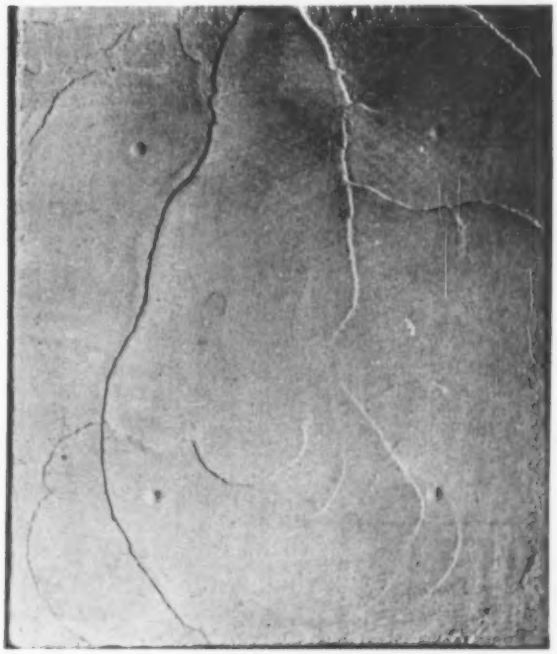


Fig. 17 — Drag surface of plate casting made in dry synthetic sand (containing 6 per cent western bentonite), showing severe rattailing. The mold was dried and allowed to stand overnight before casting.

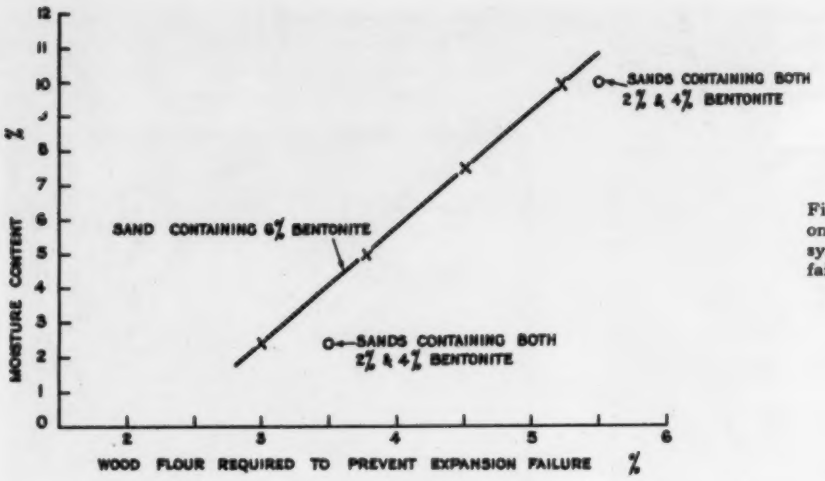

MOISTURE CONTENT %
SAND CONTAINING 6% BENTONITE
SANDS CONTAINING BOTH 2% & 4% BENTONITE
SANDS CONTAINING BOTH 2% & 4% BENTONITE
WOOD FLOUR REQUIRED TO PREVENT EXPANSION FAILURE %

Fig. 18 — Moisture content effect on amount of wood flour required in synthetic sands to prevent expansion failure in the crust separation test.

appreciable amount of additive, variation in moisture content had a significant influence on susceptibility. The conclusion to be drawn is that in practice, mold drying may have no useful effect on reducing scab or rattail defects, unless either moisture absorption from the atmosphere (and from the backing sand of skin dried molds) is completely prevented (which would mean pouring almost immediately after drying, or storing molds in a perfectly dry atmosphere), or else the sands contain an additive such as wood flour.

An interesting result was the high percentages of wood flour required in the crust separation and casting tests to prevent rattailing (e.g., with a synthetic sand containing 4 per cent bentonite and 2.4 per cent water, 3.5 per cent wood flour was shown to be insufficient, in a severe casting test). The amount of additive required in synthetic sands was obviously far too high for foundry use. It would not be economical and the sand would have unsatisfactory molding properties. The aim rather should be to use a mimimum of additive, and pay greater attention to practical aspects of molding and casting likely to affect the incidence of the defects.

The crust separation test is proposed as a simple means of reproducing in the laboratory casting conditions which are highly favorable to the formation of crust-separation-type defects. The test is still under development, and the research program for which it was devised is incomplete, but there appears good reason for believing that, as well as serving its original purpose, it will find application in routine testing in the foundry.

REFERENCES

1. Pettersson, H., "Spalling of Green Sand Moulds and its Relation to Casting Defects," *Proc. Inst. Brit. Found., vol. 48,* p. A203, 1955.
2. Ref. 1. p. A209.
3. AFS Sand Division Committee 8-J, "The Scabbing Defect," AFS TRANSACTIONS, *vol. 63,* p. 124, 1955.
4. Nicolas, P., "Behaviour of Moulding Sand at High Temperature," *Giesserei, vol. 41,* p. 337, 1954.
5. Levelink, H. G., "Behaviour of Green Moulding Sands During Shock Heating as Regards the Occurrence of Surface Defects on Castings," *Giesserei, vol. 45,* p. 4, 1958.
6. Gittus, J. H., "The Influence of Mould Factors on Casting Defects," *B.C.I.R.A. J. Res. and Devel., vol. 5,* no. 5, p. 268, April 1954.
7. Parkes, W. B., and Godding, R. G., "Behaviour of Moulding Sands at High Temperatures," *Proc. Inst. Brit. Found., vol. 48,* p. A192, 1955.
8. Ref. 1, pp. 204, 206, 210, 214.
9. Ref. 5, p. 7.
10. Ref. 1, p. A204.
11. Ref. 3, p. 135.
12. Ref. 7, p. A188.

Technical Council Outlines Plans

■ Future plans of the AFS division and general interest committees were coordinated into an over-all Society program on May 22 at a meeting of the Technical Council.

Each of the divisions and general interest committees submitted progress reports for the fiscal year and outlined future plans. Financial requests were made for conducting AFS-sponsored research.

A tentative plan for the 1960 Convention was submitted for approval or suggested changes. The Gray Iron Division suggested a jointly sponsored symposium on gating and risering. Divisions reported that technical sessions at the 1959 Congress held in Chicago were well attended.

New deadlines were announced for submitting of technical papers. Oct. 15 has been established as the deadline for receiving technical papers and all papers must be approved by Program & Papers Committees by Nov. 15.

Technical Council Chairman—H. J. Rowe, Aluminum Co. of America, Pittsburgh, Pa.
Technical Council Vice-Chairman—AFS Vice-President N. J. Dunbeck, International Minerals & Chemical Corp., Skokie, Ill.

Brass & Bronze Division

Chairman—R. B. Fischer, Ingersoll-Rand Co., Phillipsburg, N. J.
Vice-Chairman—R. A. Colton, American Smelting & Refining Co., Houston, Texas.

Education Division

Chairman—R. W. Schroeder, University of Illinois, Navy Pier, Chicago.
Vice-Chairman—G. E. Garvey, Garvey Pattern & Mfg. Co., South Bend, Ind.

Gray Iron Division

Chairman—R. A. Clark, Electro Metallurgical Co., Div. Union Carbide Corp., Cleveland.
Vice-Chairman—Harvey E. Henderson, Lynchburg Foundry Co., Lynchburg, Va.

Light Metals Division

Chairman—J. G. Mezoff Dow Chemical Co., Midland, Mich.
Vice-Chairman—S. Lipson, Pitman-Dunn Lab., Frankford Arsenal, Philadelphia.

Malleable Division

Chairman—F. W. Jacobs, Texas Foundries, Inc., Lufkin, Texas.
Vice-Chairman—L. R. Jenkins, Wagner Castings Co., Decatur, Ill.

Pattern Division

Chairman—J. M. Kriener, National Malleable & Steel Castings Co., Cleveland.
Vice-Chairman—R. L. Olson, Dike-O-Seal, Inc., Chicago.

Sand Division

Chairman—L. J. Pedicini, Congress Die Casting & Drive Div., Tann Corp., Detroit.
Vice-chairman—V. M. Rowell, Harry W. Dietert Co., Detroit.

Steel Division

Chairman—D. N. Rosenblatt, American Foundry & Machine Co., Salt Lake City, Utah.
Vice-Chairman—W. A. Koppl, International Nickel Co., New York.

Die Casting & Permanent Mold

Chairman—F. C. Bennett, Dow Chemical Co., Midland, Mich.
Vice-Chairman—R. P. Dunn, Lindberg Melting Furnace Div., Lindberg Engineering Co., Chicago.

Ductile Iron Division

H. G. Haines, Woodruff & Edwards, Inc., Elgin, Ill.
D. Matter—Ohio Ferro Alloys Corp., Canton, Ohio.

Cupola Advisory

C. F. Joseph, Central Foundry Div., GMC, Saginaw, Mich.

Management Development

L. H. Durdin, Dixie Bronze Co., Birmingham, Ala.

H. J. Rowe
Technical Council
Chairman

N. J. Dunbeck
Technical Council
Vice-Chairman

R. B. Fischer
Brass & Bronze

R. W. Schroeder
Education

Continued on page 100

AFS news and views

CONTENTS

Technical Council ... 99
T&RI Courses 101
AFS Tours 102
Regional Talks 104
Wentworth Institute . 106
Chapter News 107
Chapter Calendar ... 111

Continued from page 99

New Chairmen AFS Divisions

R. A. Clark
Gray Iron

J. G. Mezoff
Light Metals

F. W. Jacobs
Malleable

J. M. Kriener
Pattern

L. J. Pedicini
Sand

D. N. Rosenblatt
Steel

F. C. Bennett
Die Casting & Permanent Mold

H. G. Haines
Ductile Iron

L. H. Durdin
Management Development Committee

C. F. Joseph
Cupola Advisory Committee

Ontario Fourth AFS Chapter To Sponsor T&RI Program

■ Presentation of *Melting of Copper-Base Alloys*, May 4-5 at Hamilton, Ontario, Canada, marks the completion of the fourth chapter-sponsored course in the T&RI 1959 program. Ten other courses remain on the T&RI 1959 schedule.

Four chapters have cooperated with the Institute in presenting foundry subjects on a regional basis. The program opened in February with *Gating & Risering of Castings* in Birmingham, Ala., in cooperation with the Birmingham Chapter. Instructors were: Charles Locke, Crucible Steel Castings Co., Cleveland; Karl G. Presser, Buckeye Foundry Co., Cincinnati; R. A. Colton, American Smelting & Refining Co., Houston, Texas; S. C. Massari, T&RI Director and R. E. Betterley, T&RI Training Supervisor.

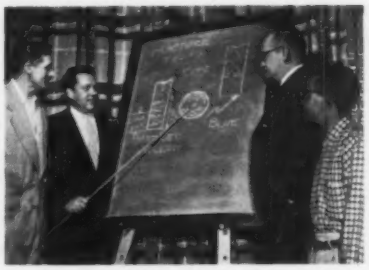
Next were the *Gating & Risering of Castings* courses in California. The Southern California Chapter presented the two-day program in Los Angeles April 24-25, and the Northern California Chapter sponsored the course April 27-28 in Berkeley, Calif. Instructors were John Varga, Jr., Battelle Memorial Institute, Columbus, Ohio with Massari and Betterley.

Harry Ahl was the instructor at Hamilton, Ont., given by the Ontario Chapter. He was assisted by Betterley.

In each of the regional courses many of the enrollees were drawn from plants located a considerable distance outside of the immediate area. At Hamilton, students were registered from the states of Michigan, New York, New Hampshire and Pennsylvania. Almost one-third of those attending were from various sections of the United States.

In Birmingham, half of the registrants were from outside of Alabama.

Reviewing material at **Ontario**-sponsored T&RI course in Melting of Copper-Base Alloys are: **D. Hunt,** International Malleable Co., Ltd., Guelph, Ontario; **D. Magder,** United Smelting & Refining Co., Hamilton, Ont.; **J. Molinaro,** International Malleable Iron Co., Ltd., Guelph, Ontario; and **T. Saray,** Dominion Engineering Works, Ltd., Lachine, Quebec.



Instructor **Harry Ahl,** Malleable Iron Fittings Co., Branford, Conn., uses pointer to illustrate point at T&RI course at **Hamilton, Ontario.** Others are: **Folke A. Landstrom,** Superior Brass & Aluminum Co., Lansing, Mich.; **K. L. Piersons,** B. Claude Piersons Foundry, Inc., Painted Post, N.Y.; **James A. Bell,** Mueller Brass Co., Port Huron, Mich.

Ontario Chapter's second sponsoring of T&RI courses, May 4-5 at Hamilton, Ont., drew foundrymen from both Canada and the United States.

Five T&RI Courses in Summer

■ Reduction of cupola operating costs through more efficient operation was presented at the AFS Training & Research Institute *Cupola Melting of Iron* course given May 11-15 at the Hamilton Hotel, Chicago.

Covered in the course were cupola design and construction, raw materials, alloys, charge preparation, blast, control of melting temperature and rate, raw materials purchasing, coke, preparing the coke bed, equipment for melt temperature measurement, combustion in the cupola, metal control, cupola records, desulfurizers, finishing the heat, slagging, operating problems, forehearth and ladles, water-cooled operations, cupola lining, metallurgy of cast iron and control and legislation of cupola emissions.

Instructors for the course were Howard H. Wilder, Vanadium Corp. of America, Chicago; Vince Boemer, Great Lakes Carbon Corp., St. Louis; W. R. Jaeschke, Whiting Corp., Harvey, Ill. and R. E. Betterley, S. C. Massari and H. J. Weber of the AFS staff.

Metallography of Non-Ferrous Metals, July 13-15 at Chicago will be the next course followed by two August courses and two September courses, also in Chicago. These are: *Core Sand Practice*, Aug. 10-14; *Gating & Risering of Castings*, Aug. 24-26; *Patternmaking*, Sept. 16-18; *Product Development and Marketing*, Sept. 28-30.

T&RI Registration

Payment of tuition fees should accompany enrollment application. Make all reservations ONLY with Director, AFS Training & Research Institute, Golf & Wolf Roads, Des Plaines, Ill. Tel. VAnderbilt 4-0181.

1959 T&RI Courses

July-Sept.

Subject and Description — *Dates*

Metallography of Non-Ferrous Metals .....July 13-15
Demonstration and work shop course for melters, supervisors, foremen, foundry engineers, researchers, laboratory technicians, metallurgists and design engineers. Basic metallurgy, terminology, phase diagrams, micro and macro analyses, mechanical properties based on metallographic interpretation and heat treatment are studied. One day on demonstrations and workshop activities in the laboratory. Metal specimens are prepared and studied. Course MTY2A, $80, Chicago.

Core Sand Practice .....Aug. 10-14
Instruction covering all phases of materials, mixing and application. The advantages and disadvantages of new materials and methods are studied. Casting losses attributed to cores are analyzed for solutions. Designed for foremen, supervisors, technicians, engineers and management. Course SC1A, $90, Chicago.

Gating & Risering of Castings .....Aug. 24-26
Instruction course covering theory and practice on the various problems relating to gating and risering. Metal flow, solidification phenomena, heat transfer, shrinkage, hot tears, ferro-static pressure, gate and riser design, mold wall movement and surface tension are some of the many facets covered. Intended for foremen, technicians, foundry engineers, industrial engineers and production and quality control personnel. Course GR1B, $60, Chicago.

Patternmaking .....Sept. 16-18
Demonstration and instruction for patternmakers, foremen, supervisors, trainees, purchasers of castings, suppliers and management—materials, equipment, layout, allowances, construction techniques and recent trends. Emphasis placed on new materials, processes, techniques and their applications. Course PM1A, $80, Chicago.

Producting Developments & Marketing ....Sept. 28-30
Instruction course on product analysis from the design to the marketing of the finished product. Study will include: casting design, stress analysis, pattern selection, equipment, cleaning operations, cost analysis, casting processes, engineering properties of cast metals and sales promotion. Scheduled for all types of foundry engineers, sales engineers, technicians, supervisors, metallurgists and management. nel. Course GR1B, $60, Chicago.

Students attending **T&RI Metallurgy of Gray Iron** course presented May 11-15 at the Hamilton Hotel in Chicago. Enrollees attending represented 11 states ranging from the east coast to Minnesota and from Trois Rivieres, Quebec, Canada, to Florida. As usual the course drew heavily from outside the city in which it was given. Illinois furnished three students, the same number as attending from Ohio.

AFS Sponsors Two European Tours . . .

■ One of the largest delegations of American foundrymen to attend an International Foundry Congress is expected at the 26th International to be held Oct. 4-10 in Madrid, Spain.

Success of the AFS-sponsored tour to the 1953 International in Paris has prompted to scheduling of two European tours. Both have been planned to accommodate time and travel preferences of AFS members and also include sufficient time for sightseeing trips and plant visits.

AFS Pre-Congress Tour A provides first-class passage on H.M.S. Queen Mary and return on the S.S. United States. The 48-day tour starts Sept. 2 from New York on the Queen Mary and includes 37 days in Europe visiting eight countries. Average first-class steamship accommodations will cost about $2000 per person.

AFS Post-Congress Tour B, 33 days total, calls for trans-Atlantic plane both ways with 31 days in Europe visiting seven countries at a cost of about $1600 per person.

Both tours are organized on all-expense, personally-escorted (in Europe) basis with Thos. Cook & Son as official travel agents.

In addition to the AFS-sponsored tours, three-post Congress tours will be conducted by the Spanish Institute of Iron and Steel, official hosts to the International. These eight-day tours will be made by motor coach. Separate tours will be made to the northern, southern and eastern sections of Spain. Receptions, plant visits and sightseeing will be included. Cost of the tours range from 3300 to 4130 pesatas or approximately $80-$100.

All arrangements for the Official AFS tours should be made with Thos. Cook & Son offices in America.

Arrangements for the post-Congress tours in Spain should be made with the Spanish Institute of Iron and Steel when registering for the International Foundry Congress.

AFS has received a supply of official programs from the Spanish Institute, including all information and registration forms for the International Congress. The program booklet also outlines the various post-Congress tours and general information on registration and fees, hotels and car rental service.

Those planning to attend should write to the AFS General Manager, AFS Central Office, Golf & Wolf Roads, Des Plaines, Ill.

The International Foundry Congress is sponsored by the International Committee of Foundry Technical Association. AFS is the sole representative of the United States. As a member, AFS will have official delegates, submit an official exchange paper and will be represented at the various meetings held at the International.

AFS Official Delegates to the International will be AFS National Direc-

Madrid, host city to the 26th International Foundry Congress offers striking contrasts between the old and new. In the foreground is the 26-story **Edificio Espana.** To the right is a monument to the Spanish author Cervantes and two bronze statutes of Don Quixote and Sancho Panza. In the upper left of the picture is a portion of the Royal Palace gardens. Madrid has many museums and art galleries including the **Paseo del Prado,** one of the most important art galleries in the world. In addition to an excellent collection of Spanish paintings it also contains many works by Italian and Flemish masters. Other schools of art and sculptury are represented as well as drawings including an exceptional series by Goya.

Joint AFS-A.W.S. Committee Making Study of Welding of Iron Castings

■ Results of a second series of tests were reviewed in January at a meeting of the joint AFS-A.W.S. Committee on the Welding of Cast Iron.

The committee is studying gray iron, malleable and nodular iron castings to provide recommendations on welding in the course of fabrication, reclamation or repair. It deals with all aspects of the welding of iron castings including the selection of filler material, welding procedures, techniques, postweld heat treatments, testing, inspection and quality control.

P. E. Brown, Massachusetts Institute of Technology, Cambridge, Mass., reported on results of three gray iron specimens welded at M.I.T. with an exothermic process.

Subcommittees were appointed to prepare preliminary reports on what to expect when welding various materials. Chairmen of the subcommittees are: gray iron, S. Low, Chapman Valve Mfg. Co.; nodular iron, W. W. Edens, Allis-Chalmers Mfg. Co.; malleable iron, S. T. Walter, Air Reduction Sales Co.

A.W.S.-AFS WELDING IRON CASTINGS — 2d SERIES — 1958
GAS WELDING CLASS 30 CI — AV TS OF HEATS 41500

Bar #	Weld App.	Frac Loc.	Tensile Str.	Remarks
144A	XSP	Middle of Weld	9,400	No Preheat
144B	XSP	HAZ-FL	7,400	No Preheat
145A	Trapped Flux	WF-FLJ	12,000	No Preheat
145B	Trapped Flux	WF-FLJ	26,300	No Preheat
146A	XSP	HAZ-F	11,000	Preheat 1000 F
146B	XSP	HAZ-F	12,400	Preheat 1000 F

. . . Taking Foundrymen to International

tor C. A. Sanders, American Colloid Co., Skokie, Ill., and AFS Technical Director S. C. Massari.

Among those attending will be former AFS Presidents Bruce L. Simpson and L. N. Shannon, who was president of the International Committee of Foundry Technical Associations during the 1953 International in Paris.

Howard H. Wilder, Vanadium Corp. of America, Chicago, is the author of the AFS Official Exchange Paper to the International. His subject is the use of inoculants and ferroalloys for the production of high-strength gray irons.

Outline of the two AFS tours:

Pre-Congress Tour

Thirty-seven days in Europe visiting eight countries, forty-eight days total. Sailing Sept. 2 on H.M.S. "Queen Mary" from New York, returning on S.S. "United States" scheduled to arrive in New York Oct. 19.

England—Six days in and about London with time for numerous foundry visits.

Norway—Fly to Oslo, two days in Norway.

Sweden—Fly to Stockholm for another two days.

Denmark—Fly to Copenhagen for two days.

Germany—Fly to Dusseldorf for three and a half days in Germany, including a full day at Aachen.

Belgium—Crack express train "Saphir" to Brussels for three days, allowing time to visit foundries in Liege.

Town of **Bacharach** on the Rhein in Germany. Both AFS tours will include stops in Germany as well as other European countries. The steamship tour will include visits to Scandinavian countries.

France—By train to Paris for two and a half days with time for spectactular sightseeing and business visits.

Spain—By overnight train "Sud Express" to Madrid. In Spain for 11 days, including side trips to Seville and Granada. Six days in Madrid for International Foundry Congress.

Finally back to Paris on Oct. 11. After day of leisure, boat-train to Le Havre for trans-Atlantic return.

Post-Congress Tour

Thirty-one days in Europe visiting seven countries, 33 days total. Flying across via T.W.A. on Sept. 30, returning Pan-American on Oct. 31.

Portugal—Arrive Lisbon, two and one half days in Portugal.

Spain—Fly to Seville, Spain for two days, then to Madrid and the International Foundry Congress for five and one half days.

Switzerland—Fly to Zurich, three and one half days in Switzerland with time for foundry plant visits.

Germany—By train to Wiesbaden, then motor coach to Koblenz, Dusseldorf and Aachen. Four and one half days in Germany. Opportunity for a number of foundry visits.

Belgium—By train to Brussels for four and one half days. Time for side trips to Ghent, Liege and Bruges.

France—Evening train to Paris for three days of sightseeing, business calls and shopping.

England—Fly to London for four days in England with opportunity to visit several English casting plants. By jet plane to New York.

Spanish Post-Congress Tours

North Tour No. 1

Visiting Segovia, Valladolid, Leon, Aviles, Altamira Caves, Santander, Bilbao, Eibar, San Sebastian and Burgos. Plant visits at Aviles, Bilboa, Eibar and San Sebastian.

East Tour No. 2

Visiting Motilla, Valencia, Benicarlo, Barcelona, Lerida and Zaragossa. Plant visits at Valencia and Barcelona.

South Tour No. 3

Visiting Manzanares, Granada, Malaga, Algeciras, Cadiz, Jerez, Seville, and Cordova. Plant visits at Malaga, Cadiz, Seville and Cordova.

Members of the joint AFS-A.W.S. Committee on the Welding of Cast Irons met in Detroit on April 16. Left to right are: **C. W. Hockman,** Cadillac Motor Car Div., GMC; **C. A. Sebastianovich,** Dominion Engineering; **H. V. Inskeep,** Linde Co.; **L. W. Thayer,** Cadillac Motor Car Div., GMC; **Paul Brown,** Massachusetts Institute of Technology; **S. T. Walter,** Air Reduction Sales Co.; **E. Fenton,** American Welding Society; **R. K. Lee,** Alloy Rods Co.; **K. Cann,** Ingersoll-Rand Co.; **Sidney Low,** Chapman Valve Mfg. Co.; **D. E. Kuhn,** Chapman Valve Mfg. Co.; **J. E. Fitzwater,** International Harvester Co.; **W. M. Spear,** Worthington Corp.; **B. M. Jones,** American Cast Iron Pipe Co.; **J. S. Vanick,** International Nickel Co.; **W. Edens,** Allis-Chalmers Mfg. Co.; **G. Dinges,** Nordberg Mfg. Co.; **C. H. Burgston,** Deere & Co.; **W. R. McCrackin,** Cooper-Bessemer Corp.; **Ray Tampir, Don Seigan, Stan Goodman, C. W. Yaw, Jerry Young,** all of Cadillac Motor Car Div., GMC.

PLASTICS in the Pattern Shop

by J. Bruce Ferguson
Allis-Chalmers Mfg. Co.
Milwaukee

Many pattern shops have adopted plastics to extend material and pattern diversification. But certain fabrication techniques or application realms encompassed by the Allis-Chalmers Plastics Department may provide useful reference information for brainstorming cost reduction ideas and new profitable activities.

MANY USES AND TECHNIQUES

We have expanded well beyond the pattern field and now use plastics for tooling fixtures, product parts, prototype designs, maintenance work, protective coatings, materials handling projects and dielectric driers. Although filled epoxy resins satisfy the bulk of our needs we are also utilizing polyvinyl chloride resins, acrylic resins, the silicones, furane resins, polyesters and polyurethanes. The various resins are applied by casting, hand lay-up, spraying, brushing, matched die molding, vacuum casting and bag molding.

PATTERN MAKING GOALS

Our initial pattern-making goals were: (1) to replace worn out or badly damaged patterns; (2) provide duplicate equipment where multiple alloy orders are recurrent; (3) make more economical design changes of a complex contour type; and (4) in some instances to make new patterns or core boxes, particularly when cost contrasted with metal equipment.

PLASTIC CEMENT

In making negative slugs from master patterns, "plastic cement" negatives have displaced plaster. A polyester resin is brushed onto the master and allowed to reach the tack stage. Then it is backed up with a putty-like mix consisting of 100 parts coarse silica sand to 6 parts by weight laminating resin.

Normally three to four inches of the cement is adequate. Curing provides a strong, dimensionally stable structure that can be used for an infinite number of positive plastic reproductions. When, because of the design shape, removal from the master or negative appears questionable, jacks are applied. These are simply nuts placed against the master and bolts screwed into the nuts. A coating of parting compound prevents adhesion of the plastic cement.

Alternating torque on stategically placed jacks effectively eject the negative from the master. The same system works for positive duplications.

CONSTRUCTION DETAILS

For parting agents two sprayable materials, a solvent dispersed wax and polyvinyl alcohol are applied, respectively. Usually twelve layers of 0.013-in. plain weave Volan treated fiberglass is adequate for the positive buildup. Mock leno weave cloth 0.030 in. thick, is finding increasing usage since the sequence four layers of 0.13 cloth, four layers 0.030 cloth eliminates the labor involved in laying up four additional layers.

For the smaller jolt squeeze work mass casting resins suffice. Larger patterns, jolt squeeze, slinger, and floor molding require reinforced laminated construction. Steel inserts at high, vulnerable areas of slinger patterns counteract erosion wear. On blow core boxes, surface cast resins backed by a lightner are employed. The lightner is a laminated shell laid up against a 0.25-in. clay covered master. Removal of the clay and repositioning the laminated lightner produces the required cavity for casting surface type resins.

THIN WALLED PARTS

In making thin walled product parts matched die molding proved appropriate. One to two layers of resin saturated cloth are laminated on the male and female portions. Closing the die squeezes out excessive resin and maintains desired wall thicknesses. Smooth, close tolerance work results.

Scale or prototype models are frequently formed off clay or plaster masters. A soft moldable clay func-

by C. M. Adams, Jr.
Massachusetts Institute of Technology
Cambridge, Mass.

HOW TO

Feed A Casting

To perform its function, a riser must be large enough, or well enough insulated, to remain liquid longer than the section of the casting it is supposed to feed. The size requirement is amplified by the fact that liquid metal will transfer from the riser to the casting, thereby shortening the solidification time of the riser and lengthening that of the casting. The results of many investigations on the subject of dimensioning risers are, surprisingly, in substantial agreement with one another. Risering can be mathematically represented by the following three expressions:

$$D = 2.5\,t + \frac{0.02\,V_c}{t^2}$$ for Plate-shaped castings

$$D = 1.25\,t + \frac{0.08\,V_c}{t^2}$$ for Bar-shaped castings

$$D = 0.83\,t + \frac{0.18\,V_c}{t^2}$$ for "chunky" castings

[V_c = volume of casting section being fed; t = section size of casting; D = diameter of riser (height = diameter, no riser treatment except top insulation)]

In general, the expression which gives the *smallest* answer for D is most correct for casting geometries which do not fall clearly into one of the three categories.

INSULATING SLEEVES AND HOT TOPS

The above relationships relate to risers which are surrounded by sand. Through the agency of insulators and heat sources, risers may be treated to increase their fluid life and decrease their size. In general, it has been shown the use of insulating sleeves on small non-ferrous castings is very effective. With large castings of high melting metals, such as steel, it is of paramount importance to treat the top surface of an open riser to minimize radiation losses. Exothermic materials, wisely employed, can reflect pronounced economies, particularly in the iron or steel foundry.

TAPERED SECTIONS

In addition to remaining liquid long enough to do its job, the riser must be so situated, and the casting so designed, that liquid metal can flow from the riser to those portions of the casting being fed. The fluid transport problem has been studied primarily in terms of the solidification and soundness of tapered sections. It has

tions as the filler material and is easily swept to template conformance. Clay, unlike plaster, does not have a limited working cycle and can be salvaged for re-use.

INSPECTION GAGES

Inspection gages are easily formed by laminating directly against a production part which has been machined and certified by the Inspection Department. Because the coefficient of expansion of laminated epoxy resin is similar to that of steel, whereas casting resins exhibit incompatible expansion characteristics, the fiber-glass resin combination is mandatory. Simplicity of duplication is particularly significant when multiple gages of the same design are required.

Plastics offer the pattern shop a new engineering material. Through judicious application choice plastics can decrease fabrication labor costs and create varied product areas with enhanced customer response.

Editor's Note: This article contains highlights excerpted from a talk presented at the 1959 Wisconsin Regional Foundry Conference.

What's Happening in Europe?

by CLYDE A. SANDERS
American Colloid Co.
Skokie, Ill.

■ RESEARCH AND DEVELOPMENT—The chemist and chemical engineer are gradually replacing the metallurgist in certain European technology . . . In the making of iron and steel, the chemist finds himself in a role not uncommon.

■ FUTURE MELTING PROCESSES—The blast furnace has always been looked upon as a necessary nuisance. Although it does not appear that direct reduction of ore will eliminate the blast furnace very soon, it may however lead to an alternate route . . In Europe there are two direct types of ore reduction; those using gaseous reducing agents in a fluidized reaction and those performed in kilns, retorts or shaft furnaces . . . These methods may lead toward the foundry . . . The Swedish Domnarfret Kiln process hopes to reach a 97 per cent iron recovery . . . The Krupp-Renn Process carries out a reduction in rotary kilns to produce iron in the form of low-carbon metallic nodules. . . . The English Cyclonic process looks best and may have a direct application for foundry use in producing pure iron. The reaction in this cyclone furnace is exothermic and the fuel is supplied by a limited amount of carbon plus oxygen . . . If the foundry is able to bypass the blast furnaces a substantial savings could be involved.

■ INDUCTION FURNACES—Induction furnaces are leading the way in European practice. Their integrated electric controls regulate the power and furnish the correct power factors for uniform melting.

■ VACUUM MELTING—VACUUM ARC MELTING—VACUUM STREAM DEGASSING—All large European companies are experimenting, or actually using, vacuum arc melting or some form of vacuum degassing . . . Gaseous deoxidized products can be pumped away rather than separated by slags. This prevents entrapment in the metal. Higher densities improve mechanical properties and cleaner metal results under vacuum . . . Hydrogen is reduced approximately 50 per cent by proper melting under vacuum with improved ductility.

■ VIBRATION TECHNIQUES—Vibration techniques, such as sonics and ultrasonics, are being developed in Europe. Supersonic reflectoscopes are being used. Magnetostriction generators are used to produce ultrasonic energy . . . Cleaner metal results and microshrinkage has diminished in cases of vibration treatment.

■ HEAT TREATMENT—Progressive European foundries have learned to do their own heat treatment and do not depend on outside sources.

■ APPRENTICESHIP TRAINING—Throughout Europe apprenticeship training is prevalent. Craftsmen teach the apprentice the art of making a mold and treat it as an art. An educated foundryman in Europe is not one who has only a formal education but one who learns to apply the tools of the trade . . . U. S. foundries could certainly adopt and practice this formality.

Editor's Note: This article contains highlights excerpted from a talk presented at the 1958 Purdue Metal Castings Conference.

been determined an extensive section of thickness, t (inches), requires a taper of 0.5/t inches per foot to completely eliminate centerline shrinkage in low carbon steel. At higher carbon contents, the term centerline shrinkage loses its meaning, but minimum taper requirements remain the same. Little or no taper is required in alloys of high thermo conductivity, such as bronze or aluminum.

FEEDING GRAY IRON

It is widely recognized that cast iron exhibits a completely different pattern of risering requirements from the standpoints of both dimensioning and location, than do other casting alloys. Eutectic cast irons exhibit very little solidification shrinkage. So in completely rigid molding environment, risers are generally unnecessary. What little feeding is necessary can be supplied by either a pop-off or the gating system itself.

In a mold which exhibits a capacity for plastic yielding, such as one of green sand, the precipitation of eutectic graphite occasions dilation of the casting. This deforms the mold and amplifies the feeding requirements of the casting. A gray iron with a true solidification shrinkage of 1 per cent will exhibit an apparent shrinkage of 4 per cent in a green sand mold.

MOLD DILATION

The demand for feed metal brought about by dilation occurs late in the solidification process after gates, pop-offs or small risers have become completely solid. This need for feed metal presents a serious threat to casting soundness. The outer layers of a gray iron casting, where graphite precipitation occurs the earliest, tend to expand and buckle. Depending upon surface geometry and the configuration of the casting, the bukling usually tends to take place in an outward direction, increasing the volume of the casting and amplifying the apparent solidification shrinkage. Under certain conditions, however, the casting walls may buckle inward, effecting self feeding to produce a sound casting.

Different irons exhibit different shrinkage behaviors in green sand molds, depending in large part upon the degree of super cooling which obtains at eutectic temperature. Thus, in one extreme example, ductile iron, precipitation of graphite takes place in almost completely solid surroundings, resulting in a pronounced tendency toward dilation and large apparent shrinkages. Yet, in a perfectly rigid mold, ductile iron exhibits the same total shrinkage as gray iron having the same carbon and silicon contents.

Editor's Note: This article contains highlights excerpted from a talk presented at the 1959 Southeastern Regional Foundry Conference.

Wentworth Becomes 13th Student Chapter

■ Four months after making preliminary inquiries about acceptance into the American Foundrymen's Society, Wentworth Institute, Boston, on April 23 became the Society's 13th Student Chapter.

Presentation of the charter was made by AFS Secretary A. B. Sinnett at the school's convocation program. Others representing AFS were Wentworth graduate Henry G. Stenberg, Draper Corp., Hopedale, Mass., AFS Director and then Region 1 Vice-President; Herbert J. Klein, Klein-Ferris Co., Boston, also a graduate and the chapter's industrial advisor; and J. Gerin Sylvia, foundry instructor at Wentworth, chapter faculty advisor and member of the New England Chapter. Sylvia has been the moving force behind the organization of the chapter.

After contacting AFS, a meeting was held at the school in February with 50 students attending. On March 12 a formal petition bearing the names of 41 students was submitted to the AFS Board of Directors with approval granted two weeks later.

Wentworth Institute, formed in 1904, offers both day and night courses. Day courses, all of which are two-year post-secondary school programs, are offered only to high school graduates with adequate secondary school preparation in mathematics and sciences. The curricula includes classroom, laboratory and shop courses which are more practical and intensive than given in engineering schools and more advanced than offered in trade school.

Students may major in metal processes industries with specialization offered in foundry operations, metal fabrication or heat treatment of metals.

First year subjects include, among others, physical metallurgy, pattern-making and casting processes. These are taken both semesters. Second year subjects include foundry, metallography, machine and tool design, metal parts manufacturing processes, strength of materials and mechanical design.

Offered under foundry options are parts manufacturing processes, experimental work on solidification of ferrous and non-ferrous metals; tooling up for production work; selection of die casting runners; gates and risers on plate and loose patterns; advanced work on shell molding, precision castings and permanent molds. Instruction and practice is given in coremaking by hand and machine.

Students' activities have included, in addition to meetings of the chapter itself, a field trip to Draper Corp., Hopedale, Mass., a joint meeting with the student chapter at Massachusetts Institute of Technology, Cambridge, Mass., use of AFS films on gating and risering and lectures from foundrymen in the area.

In an effort to improve the foundry program, Sylvia will meet with members of the New England Chapter. It is hoped that suggestions from foundrymen will aid in strengthening the curriculum and keeping it current with the latest developments in the foundry field.

In recognition for their assistance in helping Sylvia in forming the new chapter, Stenberg and Klein have been presented with photo albums by the Wentworth Student Chapter.

Student officers are:

Chairman—Anthony J. Ricci.

Vice-Chairman—Walter LaPriore.

Foundry instructor **J. G. Sylvia** discusses problems with Chapter Chairman **A. J. Ricci** on right and Chapter Vice-Chairman **W. La Priore.**

Presentation of Student Chapter Charter is made by AFS Secretary A. B. Sinnett, second from left, to **Wentworth Institute** President **H. Russell Beatty.** Others are **F. J. Boylan,** foundry instructor; AFS Director **H. G. Stenberg; H. J. Klein,** chapter industrial advisor; **J. G. Sylvia,** foundry instructor and faculty advisor.

Wentworth students meet in school foundry following presentation of AFS student chapter charter. Left to right in foreground are AFS National Director **H. G. Stenberg** Wentworth President **H. Russell Beatty;** chapter industrial advisor **J. H. Klein;** foundry instructor **F. J. Boylan** and foundry instructor and faculty advisor **J. G. Sylvia.** Forty one students joined when chapter was admitted in April. Shown in rear is school's cupola. Other melting equipment includes three non-ferrous crucible furnaces. School also has centrifugal casting machine, investment molding facilities and coremaking, die casting and CO_2 equipment.

chapter news

Twin City Chapter

Hears Talk on Resins

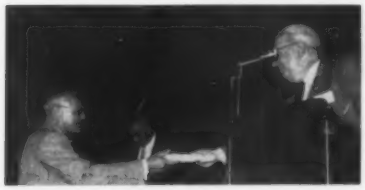
■ More than 125 foundrymen and guests at the May meeting heard O. J. Myers, Reichhold Chemicals Corp., White Plains, N. Y., discuss binders. Myers enumerated the various foundry sand binders into broad categories and their subdivisions.

In speaking on resin binders, Myers emphasized that they are not new since they have been used as components of oil binders for many years. The largest growth in resin binders is centered around the use of urea formaldahyde solutions in non-ferrous foundries and the use of phenol formaldahyde solutions in coated sand applications. Myers predicted increased use of shell cores. —*J. David Johnson*

Cold setting binder process was explained at the April meeting of the **Northwestern Pennsylvania** Chapter by Frank H. Dettore, G. E. Smith, Inc., Pittsburgh. Left to right are: Chapter Chapter Chairman **W. S. Hodge,** W. S. Hodge Foundry Co., Greenville, Pa., speaker **Dettore** and Chapter Vice-Chairman **William E. Eccles,** Cooper-Bessemer Corp., Grove City, Pa. —**Walter Napp**

Process developments which may greatly influence the future of foundries were explained at the April meeting of the **Tennessee Chapter** by V. J. Nolan, National Carbon Co., New York. Shown are **John G. Webb,** National Carbon Co.; Chapter Vice-Chairman **C. E. Seman;** speaker **Nolan** and Chapter Chairman **W. L. Austin.**

—**H. G. Nelson**



G. E. Tisdale, Lawran Foundry Co., Milwaukee, and former **Wisconsin Chapter** Chairman, presents Old-Timers award to **Anthony J. Payleitner,** Barclay Foundry, Inc., Milwaukee. —**Bob DeBroux**

Castings clinics on gray iron, steel and non-ferrous metals were conducted at the April meeting of the **Texas Chapter** held in Lufkin, Texas. Shown in picture are Past National Director **J. Klein;** Chapter Chairman **H. Judson;** Chapter Secretary **R. Smith;** Chapter Secretary **F. Jacobs; R. Lang,** Texas Foundries, Inc., **R. Colton,** American Smelting & Refining Co.; Chapter Vice-Chairman **R. Williams.** —**Harold Judson**

Awards were made recently to winners in the **Twin City Chapter** apprentice competition. Presentations were made by Chapter Chairman Robert Mulligan. Left to right: **Joe Costello,** pattern supervisor, American Hoist & Derrick Co.; pattern apprentice **Leo Strus,** American Hoist & Derrick Co.; Chapter Chairman **Robert Mulligan; Jerome Schribner** and **William Todd,** iron molding apprentices, Valley Iron Works; and **Doug Schuler,** foundry superintendent, Valley Iron Works. —**Joe Costello**

One of the many companies in the **Philadelphia** area consistently represented at the Philadelphia meetings is Bethlehem Steel Co., Bethlehem, Pa. In front row are **S. Chaubey,** exchange student from India, **E.J. Richard and J. McKerihan.** In the rear row: **K. H. Kostenbader, D. E. Best** and **E. W. Harpel.**

—**Leo Houser and Ed Klank**

One reason for excellent attendance at meetings of the **Philadelphia Chapter** is the active support from individual foundries. **M. J. Lippincott,** superintendent, Florence Pipe Foundry Machine Co., Florence, N. J. (extreme left, rear row) solicits attendance of at least eight or nine members for each meeting.—**Leo Houser and Ed Klank**

chapter news

Pittsburgh Chapter Honors Old-Timers

Thirty-six Old-Timers, all with 50 or more years in the foundry industry, were guests of the **Pittsburgh Chapter** at its May meeting. Can any chapter match this turnout? —**Walter Napp**

Four Old-Timers discuss the old days at **Pittsburgh Chapter's** May meeting honoring Old-Timers.

Chapter Vice-Chairman **J. D. Wilson,** Bronze Die Casting Co., pins 50-year pin on **R. W. Munsch** of the same company. —**Walter Napp**

Three Bay Area speakers discussed heat treatment of castings at the May meeting of the **Northern California Chapter.** Speakers and their subjects were: **Ben Berlien,** Industrial Steel Treating Co., "Heat Treating of Aluminum Alloy Castings;" **Malcolm McGregor,** General Metals Corp., "Certain Aspects of Heat Treating Gray Iron, Nodular Iron and Malleable Iron" **Richard Genger,** Pacific Steel Casting Co., "Annealing, Normalizing and Hardening of Steel Castings." —**E. J. Ritelli**

Tri-State Chapter

Cupola Operation Fundamentals

■ An illustrated talk on fundamental considerations for cupola operations was discussed at the May meeting by Walter Jaeschke, Whiting Corp., Harvey, Ill.

The talk covered combustion in the furnace as affecting melting efficiency, raw material requirements and mixing for uniformity. Jaeschke also spoke on stock distribution as affected by charging bucket design, preheated blast, duplexing for improved uniformity in composition and temperature and temperature loss in ladles.

—*Leslie O'Brien*

Pittsburgh Chapter

Conducts Look Into Past

■ Pittsburgh's May meeting, arranged by the education committee, was held in conjunction with the Pittsburgh Bi-Centennial Celebration.

A historical paper, "The Foundry Industry and its Contribution to the Growth and History of Pittsburgh," based on data gathered by Harry Kennedy, edited by George Sweetman of the *Pittsburgh Press,* was presented by M. J. Kellner, Westinghouse Electric Corp. Two old movies, taken in 1926 and 1931, showing the activities of the Pittsburgh Foundrymen's Association during those years, were viewed.

—*Walter Napp*

Wisconsin Chapter

Honors Old Timers, Apprentices

■ Old Timers and apprentices were honored at the May meeting of the Wisconsin Chapter. Additions to the chapter's old timers were Anthony J. Payleitner, Thomas G. Gradecki, Frederick A. Treder and John Mueller.

Ronald McConville

Wisconsin Chapter apprentice winners were: gray iron molding, Tom Reynolds, Richard Pipke and Kenneth Bergevain; wood patternmaking, Richard Knudsen, Richard Knoop and Bronson Phil Baker; steel molding, Arnold L. See, Wayne L. Orton and James C. Leinss; metal patternmaking, Glen Farrell, William Mathiebe and John Cseri; non-ferrous molding, Richard McConville, Louis McKee and Stanley Graff.

Raymond Dunn

Raymond Dunn, Lindberg-Fischer Div., Lindberg, Engineering Co., Chicago, addressed the chapter on "Ford's More Aluminum Foundry at Sheffield, Ala." He told of the production of die and permanent mold castings for engine and transmission parts at the huge plant. Molten metal is trucked a quarter of a mile in 5000-lb capacity covered ladles to the plant where it is transferred to holding furnaces.

Old No. 1 Being Built for Portland's Zoo

BILL WALKINS, *Editor, ESCO Ladle*
Electric Steel Foundry Co.
Portland, Ore.

■ **Old No. 1,** a replica of steam engines operating in the 1870s, will run again in Portland, Ore. The enthusiasm of citizens over the success of the streamlined train currently operating at the new city zoo has led to the construction of a 2-½ mile extension to the original 1-¼ mile line.

In response to requests for a real, old-fashioned steam train, construction has been started on old No. 1, a ¾ scale model of the Baldwin engines operating almost 90 years ago. The engine was designed by George Burton, Sherman-Clay Co., who has had considerable research experience in the design of steam locomotives. Four open-side excursion model cars, from the same era, will also be built. The train will accommodate 120 adults or 160 children.

AFS Oregon Chapter members from the area foundries and patternshops have cooperated in the effort. Pictures show: car wheels made for the Portland Zoo Railroad by Electric Steel Casting Co.; and Al Sears, Crawford & Doherty Foundry, inspecting patterns for drive wheels, journal boxes and steam cylinders.

It is hoped that the train will make its initial run during this summer's Oregon Centennial celebration. A 3600-ft. loop has been laid at the Centennial grounds where the train will operate temporarily. Income will help finance the extension of the railroad through Washington Park.

Philadelphia Chapter

Preventive Maintenance Talk

■ More than 100 foundrymen attending the Philadelphia Chapter meeting in May heard M. J. Lippincott, Florence Pipe Foundry & Machine Co., Florence, N. J., discuss preventive maintenance.

Lippincott outlined the preventive maintenance program installed at the automatically integrated pipe foundry. Several supervisors at Florence Pipe also entered the discussion on how the program was adopted and the benefits gained. Chapter Chairman T. R. Walker Jr., U. S. Pipe & Foundry Co., Burlington, N. J. presided. *E. C. Klank*

St. Louis Chapter

What's New In Foundries

■ More than 100 members and guests attended the May meeting to hear C. V. Nass, Beardsley & Piper Div., Pettibone Mulliken Corp., Chicago, discuss new equipment for small mechanized shops.

Thirty-five students from the Missouri School of Mines, Rolla, Mo., attended the meeting. The students spent the day in St. Louis touring the plants of National Bearing Div., American Brake Shoe Co. and Carondelet Foundry Co. Prof. Robert V. Wolf, faculty advisor to the student chapter, escorted the students.

—R. E. Hard

Clyde A. Sanders, American Colloid Co., Skokie, Ill., shown on left, discussed "Casting Finish, Precision and Tolerance" at the April meeting of the **Pittsburgh Chapter.** Also shown are Chapter President **I. W. Sharp,** American Steel Foundries, Verona, Pa., and Technical Chairman **W. B. Waugaman,** Westinghouse Electric Co., Pittsburgh.

—Walter Napp

Instructor Trela observes pouring in **Northeastern Ohio** sponsored workshop for foundry and pattern instructors.

Central Ohio Chapter

Sales and Quality Control

■ How Central Foundry Div., GMC, works with customers to select the best production method and the most economical design was discussed at the May meeting by T. E. Smith, Central Foundry Div., GMC, Danville, Ill.

Smith stated that the casting congresses held by General Motors had been well received. He also outlined the use of cobalt 60 in the designing of castings. *—Joseph A. Riley, Jr.*

chapter news

New **Saginaw Valley** officers —first row: Secretary **John L. Lowe;** Treasurer, **Frank A. Burke;** Director, **Steve Spess.** Second row: Director, **G. E. Savage;** Vice-Chairman, **G. R. Frye;** Chairman, **Ormond Requadt;** Director, **A. H. Karpicki;** Director, **K. H. Priestley.** —**John R. Fraker**

Past Chairmen of Tri-State Chapter met at the May meeting. Front row, left to right: **Dale L. Hall,** 1948-49, Oklahoma Steel Castings Co.; **C. A. McNamara,** Jr., 1949-50, Big Four Foundry; **R. W. Trimble,** 1947-48, Bethlehem Supply Co. Rear row: **W. H. Mook,** 1955-56, Bethlehem Supply Co.; **Edward O'Brien,** 1957-58, and **D. W. MacArthur,** 1954-55 both of Oklahoma Steel Castings Co.; **Dan A. Mitchell,** Progressive Brass Mfg. Co.
—**Leslie O'Brien**

Certificates of appreciation were awarded to outgoing officers and directors of the Tri-State Chapter in May. Left to right are Director **T. H. Lahmeyer,** Lahmeyer Pattern Works, Tulsa, Okla.; Chairman **Emmett Hines,** Nemco Foundry Co., Tulsa; Vice-Chairman **William Pitts,** Oklahoma Steel Castings Co., Tulsa; Director **Hilbert Hibbs,** Oklahoma Steel Castings Co., Tulsa. —**Leslie O'Brien**

Despite the fact that it was Ladies' night for the **Pittsburgh Chapter,** they were excluded from the chapter's Sweet Septet as it softly sung the old favorites.
—**Walter Napp**

Members of Pittsburgh Chapter's entertainment committee which arranged Ladies' Night and Dinner Dance. Mr. and Mrs. **H. C. Sterling,** Mr. and Mrs. **J. J. Curran,** Mr. & Mrs. **I. W. Sharp,** Mr. and Mrs. **M. J. Kellner** and Mr. and Mrs. **W. H. Sarraf.** The party was attended by 110 members and guests.

O. J. Myers, Reichhold Chemicals Corp., addressing May meeting of **Twin City** Chapter on binders.

Saginaw Valley members in May heard William Illuminati, International Automation Corp., Ann Arbor, Mich., explain an automated molding and pouring method. Shown are Technical Chairman **G. E. Savage,** Buick Motor Div., GMC, Flint, Mich.; speaker **Illuminati;** Chapter Chairman **A. H. Karpicki,** Central Foundry Div., Saginaw Malleable Iron Plant, Saginaw, Mich.

Wisconsin apprentices who won first and second places in non-ferrous molding division of National Apprentice Contest: **Stanley Graff,** Eck Foundries, Inc., Manitowoc; **Ronald McConville,** Nordberg Mfg. Co., Milwaukee.
—**Bob DeBroux**

Charles W. Mooney, Jr., Olney Foundry Div., Link-Belt Co., Philadelphia, addressed the New England Chapter in May on sand problems and their solutions encountered by Olney Foundry. Left to right: New England Chapter Chairman **William H. Ohlson,** Draper Corp., Hopedale, Mass., speaker **Mooney, Newton Williams,** Geo. Pettinos Co., New York.
—**J. H. Orrok & F. S. Holway**

afs chapter meetings

JULY

Philadelphia . . July 17 . . Manufacturers Golf & Country Club, Oreland, Pa. . . *Annual Summer Outing.*

Wisconsin . . July 24 . . Golf Bowl, 14 miles south of Milwaukee . . *Annual Outing.*

AUGUST

British Columbia . . Aug. 8 . . Horseshoe Bay, British Columbia . . *Salmon Derby.*

Canton District . . Aug. 1 . . Brookside Country Club, Barberton, Ohio . . *Annual Picnic and Golf Party.*

St. Louis District . . Aug. 8 . . Shady Acres Resort, St. Louis County . . *Picnic.*

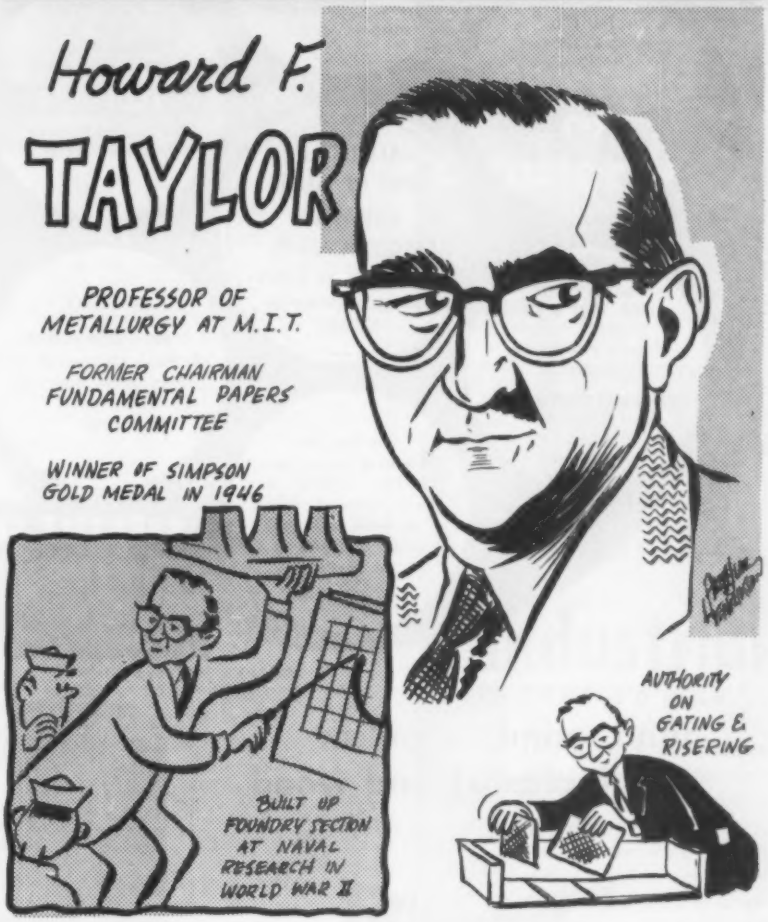
Southern California . . Aug. 8 . . Lakewood Country Club, Lakewood, Calif. . . *Summer Stag and Golf Tournament.*

Twin City . . Aug. 17 . . Midland Hills Golf Club, St. Paul . . *Annual Golf Party.*

R. J. Vandan Heuvel, Milwaukee Chaplet & Mfg. Co., Milwaukee, show on left, congratulates **Thomas G. Gradecki** Zenith Foundry Co., Milwaukee, as a recipient of one of the four Old-Timer plaques given by **Wisconsin Chapter.**

Incoming **Eastern Canada** Chairman **A. H. Lewis,** accepts gavel from outgoing Chapter chairman **Max Reading.**

personality


Howard F.
TAYLOR
PROFESSOR OF METALLURGY AT M.I.T.
FORMER CHAIRMAN FUNDAMENTAL PAPERS COMMITTEE
WINNER OF SIMPSON GOLD MEDAL IN 1946
BUILT UP FOUNDRY SECTION AT NAVAL RESEARCH IN WORLD WAR II
AUTHORITY ON GATING & RISERING

Hostesses at the Pittsburgh Chapter party were **Mrs. George V. Cruickshank, Mrs. Walter H. Sarraf** and **Mrs. W. B. Hyland.**

—Walter Napp

M. J. Kellner, chairman of the Pittsburgh Chapter Ladies' Night and Dinner Dance committee, and co-chairman **W. H. Sarraf** present door prize to **Mrs. David C. Tiani.**

Honored at Eastern Canada's recognition night were: **R. Lord,** National Apprentice Winner; **R. Labelle,** 2d place, chapter writing contest; **J. Strachan,** apprentice committee; Chapter Chairman **Max Reading; W. Tibbits,** papers committee; **N. Notte,** 1st place, chapter writing contest; **E. Jurvchuck,** 3d place.

BLASTRITE

SHOT and GRIT

A complete range of sizes, standard or made-to-order.

CHILLED CAST IRON SHOT & GRIT

For tough cleaning jobs or surface finishing of heat-treated parts.

STEEL SHOT & GRIT (Hardened and Drawn Cast Steel)

Ideal for cleaning and peening where carry-out and abrasive loss are minimized.

CALL US FOR ANY OF YOUR ABRASIVE REQUIREMENTS

Phone: Lyceum 2-2816
Teletype: Springville NY 502

HI-ALLOY "A" IRON SHOT & GRIT

Hi-strength reduces fracturing due to impact.

MALLEABLE SHOT & GRIT

Best for impact type cleaning machines.

CUT STEEL WIRE SHOT (Hard Drawn Cut Steel Wire)

Extensively used in peening springs and other metal parts.

Catalog No. AB-53 will give you further details on these stocked items, as well as those manufactured as ordered.

Free cost system installed

A S G

ABRASIVE SHOT & GRIT COMPANY INC.

Phone: Lyceum 2-2816 Teletype: Springville NY 502

manufacturers of BLASTRITE quality abrasives

Circle No. 165, Page 131-132

Sand, grind, or polish metal, plastics and wood

"Oliver" No. 381 Heavy Duty, Oscillating Single Spindle Sander and Metal Grinder

Available with power tilting feature, operated by foot control. Dial at right indicates degree of tilt. The No. 381 is rigidly built to provide low cost operation, high efficiency. Rugged, it stands up under most adverse conditions.

OLIVER MACHINERY COMPANY
GRAND RAPIDS 2, MICHIGAN

Circle No. 166, Page 131-132

M. HOLTZMAN METAL CO.

SMELTERS AND REFINERS
SINCE 1900

HOLMCO

GUARANTEED Brass, Bronze and ALUMINUM INGOT to your specifications IMPROVED WITH FACTOR "X"!

Send us a sample order! If you want to improve the quality of your finished products at no additional cost . . . let us show you what HOLMCO ingot, improved with Factor "X" can mean to you!

5223 McKISSOCK AVE., ST. LOUIS, MO.

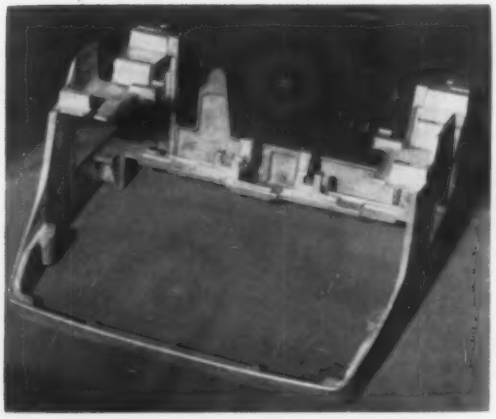
CHestnut 1-3820

Circle No. 167, Page 131-132

ENGINEERED CASTINGS SHOW

Continued from page 34

Here's How Gillett & Eaton, Inc., Lake City, Minn., casts a bi-metal diesel piston to eliminate problem of burning through the head and top ring lands. On the right is the as-cast high alloy gray iron piston cap prior to its mechanical lock and metallurgical bond to the hypereutectic high silicon aluminum alloy piston body. Completed piston is shown on left. Iron cap is set in green sand drag and aluminum poured into mold. Company makes a variety of sizes, shapes and designs to meet needs.



Here's How Doehler-Jarvis Div., National Lead Co., Toledo, Ohio, die casts a one piece typewriter frame weighing only 3.5 lb in aluminum. A savings of 50 per cent was effected by converting five separate die castings into this single unit. Elimination of assembly costs is a feature attracting attention of most typewriter manufacturers.

Here's How Hica Inc., Shreveport, La., uses the Shaw process to cast a thrust reverser hinge support clam shell for a Boeing 707 jetliner. This 347 stainless steel casting weighs 14 lb and has 112 dimensions held to ±0.030 in. Casting is made in two piece mold with two cores, all ceramic.

easy

one-man pouring on smaller jobs

Industrial

TYPE 10 BCR

TYPE 10 BCR incorporates all the "big ladle" features for precision control—yet it's specially designed for easy, one-man handling of the entire pouring operation. Offers these features to assure safe, fast and accurate performance: Easily removable sealed Anti-Friction Trunnion Bearings; Taper Side Welded Bowl with Lugs attached; Bowl Cover; and Universal Square Bail drilled for Distributor.

Send your pouring problems to us. Ask for the latest catalog on our complete line of standard and custom pouring and handling equipment.

Industrial
EQUIPMENT COMPANY
271 OHIO ST., MINSTER, OHIO
Circle No. 168, Page 131-132

foundry trade news

MAGNESIUM ASSOCIATION . . has re-elected Otis Grant as president. Other officers also re-elected to a second term were vice-presidents Charles Howe and John Thomson, and treasurer Norman Gzowski. Jerry Singleton was again named executive secretary.

Newly elected directors were: J. E. Pepall, R. D. Taylor, Edward Christiansen, William Wilson, Elmer Lanfranke and Lewis Favorite.

MALLEABLE FOUNDERS' SOCIETY . . has named P. C. Potter and C. D. Evans, Central Foundry Div., General Motors Corp., as winners in the 1959 Redesign and Conversion Contest. The winning entry was the redesign of an automobile door hinge to ferritic malleable iron.

FOUNDRY EDUCATIONAL FOUNDATION . . the Industry Advisory Committee for Pennsylvania State University recently presented scholarship certificates to several students currently receiving F.E.F. scholarships.

AIRCRAFT CASTINGS ASSOCIATION . . elected C. E. Haney as president at the annual meeting held in Los Angeles. Other officers elected at the meeting were William Stevens, vice-president; and Dar Howell, secretary. The Aircraft Castings Association was founded in 1957 by representatives from several steel and alloy foundries. The purpose of the organization is to promote and develop interest, acceptance and use of ferrous castings in the aircraft-missile industry; to achieve and maintain a high standard of quality for castings; to work with government agencies; and to promote research and development.

H. K. Porter Co., Inc. . . . New York, completed over 75 per cent of the multi-million dollar sea water magnesia and basic refractories plant in Pascagoula, Miss. Division officials estimate production will start late this year. Expected to be one of the most modern refractory brick making operations in the country, they will produce chrome-magnesite, magnesite-chrome and periclase type basic brick in burned, unburned and steel-encased bodies.

Monarch Aluminum Mfg. Co. . . . Cleveland, has recognized field sales of the commercial division. Changes reflect continuing analysis of current market conditions with an eye to most effective liaison with existing and potential customers. W. V. Tracy, general sales manager stated that G. C. Liebel will manage the Eastern territory; Joseph Shrier will handle the Central territory; M. S. Hutchinson has been assigned Western territory. Monarch is one of the nation's largest producers of aluminum permanent mold castings, aluminum die castings and certified zinc die castings.

Sunbeam Equipment Corp. . . . a newly formed subsidiary of Sunbeam Corp., has purchased most of the assets formerly used by Industrial Furnace Div., Westinghouse Electric Corp., including design and engineering files, equipment and production facilities in Meadville, Pa. The operation included a line of industrial furnaces for production processing, designed for all types of fuels. Similar type equipment, manufacturing service and replacement pars for equipment previously produced will be continued.

General Smelting Co. . . . Philadelphia, has announced two managerial changes. J. N. Pomeroy, Jr. was elected president and stepping up to post of chairman of the board and senior consultant is former president J. N. Pomeroy. Plans are in the advanced stage for an extensive expansion and product diversification program.

Pusey & Jones Corp. . . . Wilmington, Del., performed the largest single metal pouring operation in more than ten years when paper machinery builder cast a 37-ton Yankee dryer cylinder. The dryer will be delivered to Peavey Paper Mills, Inc., Ladysmith, Wis. for use in tissue paper manufacturing. Casting, a cylindrical unit 10-ft in dia and 15-ft long, cooled for seven days, and then went to machine shop to be finished.

Consolidated Iron-Steel Co. . . . Cleveland, has acquired plant, machinery and equipment and inventory of Ohio Foundry Co. Ohio Foundry Division of Consolidated will continue its manufacture of light and heavy castings. H. J. Trenkamp and Henry Trenkamp, Jr. grandsons of the founder, will become executives and Joseph Hanks, Jr., vice-president of the parent company will be in charge of the new operation.

Hamilton Foundry Inc. . . is the new name of Hamilton Foundry & Machine Co., Hamilton, Ohio. Along with the name change, a $150,000 modernization program was announced by Peter E. Rentscher, Hamilton's president.

Ertl Co. . . will build a zinc and aluminum die casting plant at Dyersville, Iowa. Headquarters for Ertl Co. are at Dubuque, Iowa.

Archer-Daniels-Midland Co. . . has won a certificate of commendation from the National Safety Council for the excellent safety record of its Cleveland plant.

Keokuk Electro-Metals Co. . . has been merged into Vanadium Corp. of America. The business and production of the Keokuk, Iowa, producer of silvery pig will be continued as a division of Vanadium Corp.

Ajax Engineering Corp. . . is now operated as a division of Ajax Magnethermic Corp., Youngstown, Ohio. Ajax Engineering will continue to maintain headquarters at Trenton, N. J.

Arwood Precision Casting Corp. . . has announced a program of plant expansion or modernization in all four of its investment casting plants. Arwood's facilities are located at Los Angeles; Groton, Conn.; Tilton, N. H.; Brooklyn, N. Y.

Paxton Mitchell Co. . . has completed a new, 30,000 sq ft gray iron foundry as an addition to its existing facilities at Omaha, Neb. The new facility will double the company's production.

Electro Metallurgical Co. . . has changed its name to Union Carbide Metals Co. The operation, a division of Union Carbide Corp., will continue to market its products under the trade

Continued on page 116

Report from Jim Coleman,
41-year veteran
Core Superintendent,
Wellman Bronze & Aluminum
Company, Cleveland, Ohio

"We scrapped 10 TONS of MISTAKES!"

"... our customer wasn't pleased. We were exceeding dimensional tolerances on a large magnesium casting. The trouble was core sag. ADM offered to work with us on the problem. We made a 1200 lb. trial mix* using **ADMIREZ UP-15.** Core sag stopped—accuracy and finish improved—our customer is happy again. As a result we actually threw out twenty 960 lb. "borderline" core sets made with the previous binder. We followed up with a more extensive test and found some bonus benefits—faster baking, higher collapsibility and less stickiness. The men say there's a lot less smoke and objectionable odor, too. We tried **ADMIREZ UP-15** ... we saw it work ... we bought **ADMIREZ UP-15** ... it's that simple. We've had excellent results with **ADCOSIL**** too."

*Formulas on request

**ADM's CO_2 Binder

Write for more information on the full line of **ADMIREZ** products manufactured by—

Archer QUALITY

Archer-Daniels-Midland company

FEDERAL FOUNDRY SUPPLY DIVISION

2191 West 110th Street • Cleveland 2, Ohio

Circle No. 173, Page 131-132

If you're troubled with gas porosity, oxides or poor fluidity in iron castings, try

Foseco® FERROGEN

scavenging compound

This bulletin gives the details. Send for your free copy today.

Foseco®

FOUNDRY SERVICES, INC.

P. O. Box 8728, Cleveland 33, Ohio

Circle No. 183, Page 131-132

foundry trade news

Continued from page 114

mark "Electromet". The unit produces ferroalloys, chromium, silicon, vanadium and other metals in six plants in the U. S.

Nelson Metal Products Co., Inc. . . has been sold to Midland-Ross Corp. The Grand Rapids, Mich. firm produces zinc and aluminum die castings.

New Iron Foundry Co. . . will construct an addition that will double production at its Romulus, Mich. plant.

Trenite Foundry Corp. . . has closed its plant at Trenton, N. J. after more than 50 years of operation.

Foundry Equipment Ltd. . . has formed a new associate company, F. E. (South Africa) Ltd. with headquarters at Johannesburg. Foundry Equipment also has associate firms in North America, Australia and Spain.

Ohio Ferro-Alloys Corp. . . . announces they have put into operation facilities which reportedly double the company's production of calcium silicon and calcium manganese silicon. The new facilities are located at the firm's Philo, Ohio plant.

The alloys are said to find use in production of wrought steel as a deoxidizer and degasifier, cleansing the metal. Ohio-Ferro also reports that these alloys are widely used by steel foundries to improve physical properties of the metal and minimize the tendency toward the formation of undesirable inclusions which lower physical properties.

Southern Die Casting Co. . . is the company name of a new zinc alloy die caster at Miami, Florida. A. L. Homery, president of the new firm, states that it will specialize in zinc alloy castings to 2 lb. Castings will include hardware for aluminum windows and doors in addition to electronic, appliance, and instrument components. The company will also offer specialized engineering and design assistance to manufacturers for product development and improvement.

Standard Financial Corp. . . has announced that it will set up installment sales programs for producers of production equipment for use in foundries. The New York firm will provide complete financing and handle all customer credit and collection for the new program.

WHO'S GOT HANDLEBAR HARRY?

Valuable asset: QUALITY

QUALITY—uniform quality ton after ton after ton—is one of the most important assets you can have in the coke you buy.

At Semet-Solvay, coke quality begins at the mine, where we sample every ton of coal, checking for impurities and measuring the coking qualities. At our coke plants, daily tests in sole-heated furnaces and giant test ovens detect and correct variations that might impair coke quality. Production samples are tested daily for uniformity, strength and proper chemical analysis.

Buying foundry coke from Semet-Solvay offers you other advantages, too: Four strategically located plants for fast, dependable service... five different sizes of coke to meet individual cupola and melting requirements ... the services of metallurgical experts to assist you on foundry problems.

If you are not already using Semet-Solvay foundry coke, why not find out now how it can help you obtain a hotter, cleaner, faster cupola operation? Just contact your nearest Semet-Solvay office or write directly to us for complete details.

Sampling coal at the mine—one step in Semet-Solvay's quality-control program to assure you of better melting coke.

Allied Chemical

Yours for better melting...

SEMET-SOLVAY DIVISION

Dept. 555-BI, 40 Rector Street, New York 6, N.Y.

BUFFALO · CINCINNATI · CLEVELAND · DETROIT

IN CANADA: ALLIED CHEMICAL CANADA, LTD., SEMET-SOLVAY DEPT., TORONTO

WESTERN DISTRIBUTOR: WILSON & GEO. MEYER & CO., SAN FRANCISCO · LOS ANGELES

Circle No. 170, Page 131-132

question

HOW DO YOU SELL TO FOUNDRIES?

answer

advertise in the foundrymen's own magazine

why

because

modern castings

- . . . reaches every known foundry in the United States and Canada
- . . . publishes top technical editorial material (and more pages of it!)
- . . . is best read (reader inquiry results prove this)
- . . . is published by *the* technical society of the industry
- . . . produces most direct response for advertisers

If you want the maximum advertising results be sure your schedule includes the magazine that produces maximum reader response!

For more information drop a line to . . .

modern castings

published by
American Foundrymen's Society
Golf and Wolf Roads
Des Plaines, Illinois

let's get personal

Joseph L. Dow . . . is now New England district engineer, Elyria Foundry Div., Chromalloy Corp., Elyria, Ohio. He was formerly with Portland Machine Tool Works, Portland, Me. **John C. Harwood** is district sales engineer, covering Wisconsin, Illinois and Indiana for Elyria Foundry Div., Chromalloy Corp., Elyria, Ohio. He was formerly sales engineer for Hansell-Elcock Co., Chicago.

John Fuqua . . . is now chief plant metallurgist, Cooper Alloy Corp., Hillside, N.J. He was formerly senior research metallurgist, American Steel Foundries, East Chicago, Ind.

C. F. Joseph

S. A. Glueck

J. G. Buzzard . . . has been named sales representative, Ohio Ferro Alloys Corp., with headquarters in Pittsburgh, Pa. He is a member of the AFS Pittsburgh Chapter.

Charles D. Preusch . . . is now materials and process engineer, Crucible Steel Co. of America, Pittsburgh, Pa. He was formerly chief metallurgist at the company's Spaulding works in Harrison, N.J.

Herbert C. Philander . . . is now sales promotion manager, North American Refractories Co., Cleveland. He was formerly with Illinois Clay Products Co.

Carl F. Joseph . . . technical director, Central Foundry Div., GMC, Saginaw, Mich., has been awarded the McCrea medal by the Malleable Founders Society for . . . "His long standing success in the field of metallurgy and in more recent years his wonderful contribution in the field of pearlitic malleable." He is Chairman of the AFS Cupola Advisory Committee, holds an Honorary Life Membership in AFS and has been the recipient of the AFS William F. McFadden Gold Medal.

George E. Austin . . . sales engineer for Link-Belt Co. in Spokane, Wash., since 1951, is now district manager with headquarters in Spokane succeeding **Homer A. Garland.** Garland continues as supervisor of the Spokane factory branch store.

R. W. deWeese . . . vice-president, sales, Electric Steel Foundry Co., Portland, Ore., has received the "Silver Knight of Management" award presented by the Greater Portland Management Club.

Robert W. Sundeen . . . is a sales engineer with Inductotherm Corp., Delanco, N.J. He was formerly a sales and application engineer with Allen-Bradley Co.

M. Earl Saxman . . . is plant manager of the Chicago district plant at Lansing, Ill., of Vulcan Mold & Iron Co. He was formerly foundry superintendent at the company's Latrobe, Pa., plant; **Arthur Moynihan** is Lansing foundry superintendent and **Jack I. Countreman** is now personnel manager.

Samuel A. Glueck . . . has been appointed as assistant to the president of H. Kramer & Co., Chicago. For the past 25 years Glueck has been with the Federated Metals Div., American Smelting & Refining Co.

Richard S. Moyer . . . previously general manager of Link-Belt Co., North Central Div., Minneapolis, is assistant to Richard E. Whinrey, vice-president in Indianapolis. Moyer is succeeded at Minneapolis by **George Ramsden.**

James W. Long . . . is manager of sales and engineering, Magnesium Alloy products Co., Compton, Calif. Other appointments: **Robert L. Oeffner,** sales mangaer specializing in magnesium sand castings; **Gilbert Finch,** supervisor in charge of the special alloy department.

Clifford S. Mehelich . . . is now abrasive sales engineer with Pangborn Corp., Hagerstown, Md. Previously he was sales engineer with Minnesota Mining & Mfg. Co. for nine years.

Herman R. Brown . . . is now sales manager, Payloader Div., Frank G. Hough Co., Libertyville, Ill. Other promotions:

Continued on page 122

DESULPHURIZATION...

LINDE's desulphurization method, for use with calcium carbide, is simple, efficient, and economical. The principal parts, shown here, are nitrogen supply, dispenser, and injection tube.

You get uniform results with Metallurgical Carbide from LINDE

In the foundry, you can produce high grade iron only by making sure you use metal with a low sulphur content. As a desulphurizing agent, metallurgical calcium carbide assures *uniformity* in the metal you produce. You know in advance that by adding a certain amount of carbide you remove a certain percentage of sulphur. Because metal specifications can be met efficiently and economically with carbide, you eliminate any need for wasteful "trial and error" methods.

Linde's method of mixing UNION calcium carbide and molten iron is simple and sure. A stream of fine mesh carbide and nitrogen under pressure is forced from a dispenser through a hose. The graphite injection tube is immersed deep in the hot metal. The carbide blends evenly and thoroughly with the iron. Desulphurization with UNION calcium carbide creates no fumes, does not attack refractories. The LINDE equipment—nitrogen supply, dispenser, and injection tube—is easy to operate and maintain.

If you would like more information about LINDE's method of desulphurization, using calcium carbide, just call or write your nearest LINDE office. LINDE COMPANY, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. Offices in other principal cities. In Canada: Linde Company, Division of Union Carbide Canada Limited.

Linde
TRADE-MARK

UNION CARBIDE

The terms "Linde," "Union" and "Union Carbide" are registered trade-marks of Union Carbide Corporation.

Circle No. 171, Page 131-132

classified advertising

For Sale, Help Wanted, Personals, Engineering Service, etc., set solid . . 25c per word, 30 words ($7.50) minimum, prepaid.

Positions Wanted . . 10c per word, 30 words ($3.00) minimum, prepaid. Box number, care of **Modern Castings,** counts as 10 additional words.

Display Classified . . Based on per-column width, per inch . . 1-time, $18.00 6-time, $16.50 per insertion; 12-time, $15.00 per insertion; prepaid.

SUPERINTENDENT WANTED

For non-ferrous foundry. Large well-established bronze and aluminum foundry. Excellent opportunity for ambitious experienced man to eventually take charge of foundry operations. State fully qualifications, experience, salary desired. **Box F-184, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SALES REPRESENTATIVE

We are interested in securing the services, on a salary plus basis, of an aggressive sales engineer to contact and sell the foundry trade. Must have a metallurgical background or equivalent practical foundry experience. Our company is prominent in its field, presently selling a widely used product to all types of foundries.

Man desired should not be over 40 years of age, preferably 30 to 35, free to travel extensively. Headquarters in a medium size Midwestern town with moving expenses paid.

Send complete resume on education and experience and salary requirements. All inquiries held in strictest confidence. Please reply to **Box F-182, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Illinois.**

PLANT ENGINEERS

Experienced on layout of all types of foundry equipment, material handling and material flows. Send complete details on work history, education and family status. Include recent photograph. All replies confidential. **Box F-140, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY SUPERINTENDENT

—Well established and rapidly growing jobbing foundry in New England producing general run aluminum and bronze sand castings but specializing in nickel alloys and stainless steels operating two shifts with about 60 men needs experienced, intelligent and progressive superintendent who can control quality, costs and production. Write giving qualifications in detail and salary requirements. **Box F-180, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

GOOD FOUNDRYMEN

when you need SUPERVISORY or TECHNICAL men why not consult a man with actual foundry experience plus 15 years in finding and placing FOUNDRY PERSONNEL.

Or if you are a FOUNDRYMAN looking for a new position you will want the advantages of this experience and close contact with employers throughout the country.

For action contact: John Cope

DRAKE PERSONNEL, INC.

29 E. Madison St. Chicago 2, Illinois

Financial 6-8700

FOUNDRY SUPERINTENDENT

Wanted superintendent for small non-ferrous sand castings foundry in Rockford, Ill. area. Must have complete knowledge and experience in melting, gating and rigging of patterns. Sand control and sundry practices of a sand castings non-ferrous foundry. Give full qualifications and references. **Box F-156, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

INDUSTRIAL ENGINEER

Experienced in foundry operations as well as general industry. Capable of taking over management of industrial engineering division of ACME member consulting firm. Degree necessary. Age 35-45. Send complete details and include recent photograph. All replies held in confidence. **Box F-135, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SALES ENGINEER

High alloy and stainless steel castings. Must be graduate metallurgist with some sales experience. Send complete resumé with photo if possible and include salary desired. Excellent opportunity with old and well established foundry located in Mid-West producing high and low alloy as well as carbon steel castings. **Box F-181, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY SALES ENGINEER for Gray Iron and Alloy Iron Castings. Age up to approximately 40. College graduate, or equal foundry technical and practical experience will be considered. Midwest. Car necessary. Very limited travel required. Will give adequate inplant and sales training for trainee. Salary open. All replies held in confidence. **Box F-188, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

METALLURGIST, FOUNDRY

Foundry metallurgist with B. S. degree, or equivalent technical knowledge, with experience in cast iron foundry operations. Must be capable of establishing controls for melting and supervising expanding metallurgical laboratory.

Should be interested in attractive, long-term opportunities with medium size manufacture.

Salary open depending on experience. Fringe benefits above average, with noncontributory surgical, hospitalization and profit-sharing program. **Box F-153, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

SALES MANAGER FOUNDRY

Division of A.A.A. National Corporation requires a top sales executive to plan and direct all sales activities of this Division's medium-size foundry. Sales experience must have been in high-alloy stainless heat and corrosion-resistant castings. Location in Western New York State. Executive type fringe benefits. Response to qualified applicants only. Forward detailed resume, including past earnings to **Box F-186, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOUNDRY ESTIMATOR

Large aluminum and bronze jobbing foundry requires man with practical foundry experience to handle estimating, expediting, and customer contact. Some previous experience in estimating desirable. State qualifications and salary desired. **Box F-185, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

WANTED:

Metallurgist with experience in production of ductile iron from basic cupola. Plant located in the South. **Box F-190, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

Mature, settled man. Handle all office and book-keeping detail in medium small nonferrous jobbing foundry. Participating plan. Stability, reliability, capability, integrity are required traits. This opportunity will be filled by July or August. **Box F-187, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

REPRESENTATIVE WANTED

We have several good territories open on our refractory cupola gun mixes for cupolas and ladles. Our products well-established with some of largest users. Reply to **Box F-191, MODERN CASTINGS Golf and Wolf Roads, Des Plaines, Ill.**

Established
Manufacturer's Representative

Calling on industry in North Jersey and Metropolitan New York and desire an additional line in steel or other metals and metal parts. Have done a good job for others and believe I can do it for you.

Box F-189
MODERN CASTINGS
Golf and Wolf Roads, Des Plaines, Ill.

FOUNDRY SALES REPRESENTATION Aggressive young man, 29, four years foundry sales experience, (grinding wheels) has opportunity to diversify. Would like to handle two or three additional foundry items, giving specific product concentration. Presently covering Southeast from Birmingham. Best references. **Box F-174, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

MANAGER - SUPERINTENDENT Forty-six year old executive. Technical and practical experience in heavy and light jobbing and production ferrous and non-ferrous foundries. Capable and progressive; 20 years in supervisory and sales capacity. Now employed. **Address Box F-183, MODERN CASTINGS, Golf and Wolf Roads, Des Plaines, Ill.**

FOR SALE

2 Lindberg Radiant Fired Electric Furnaces, complete with controls, 440 V, 50 KW. **Aluminum Match Plate Corp., 1500 Military Rd., Buffalo 17, N. Y.**

KUX DIE CASTING MACHINES

Model K-5, 25-T. Locking Pressure new 1949, Weight 2200#, Extra equipment and brand new.
Model BA-12, 100 T Locking Pressure, new 1948, Weight 8500#. Very reasonable. Excellent condition. Model #2-DC REED PRENTICE, 400 T. Locking Pressure, Complete zinc new '51, running. Excellent.
EVEREADY, Box 638 BPT., CONN.
EDison 4-9471-2

FOR SALE

Fairbanks-Morse Co., Three Rivers plant, Three Rivers, Mich. Telephone number 3-1245.

McCann-Harrison stress relieving furnace. Car-type, size 16-ft, 10-in. 9-ft 9-in. x 8-ft. Car 14-ft x 7-ft 6-in. Oil operated 1500 F. Price $975.00.

84-in. Diamond Face Grinder—Diamond of Cup Wheel 30-in. Working surface of table 84-in x 24-in. Table over-all 132-in. x 24-in. 30 H.P. A.C. Motor excellent for grinding heavy castings, etc.

The above now under power. Contact representative of Weiss Steel Co. at plant.

EARL E. WOODLIFF
Foundry Sand Engineer
Consulting . . . Testing
14611 Fenkell (5-Mile Rd.)
Detroit 27, Michigan
Res. Phone VErmont 5-8724

FOUNDRY CONSULTANT — NONFERROUS Sand—permanent mold—centrifugal permanent mold—and centrifuge permanent mold. High pressure castings a specialty. Address: ED JENKINS, 253—8th STREET, WEST PALM BEACH, FLORIDA, PHONE: TEMPLE 2-8685.

BACK VOLUMES — Wanted to buy for cash of foundrymen, TRANSACTIONS American Foundrymen's Society and other scientific technical Journals, **A. S. ASHLEY 27 E. 21, N. Y. 10, N. Y.**

NEW SERVICE

MODERN CASTINGS announces a new service available to all members of the American Foundrymen's Society. Any member seeking employment in the metal-castings business may place one classified ad of 40 words in the "Positions Wanted" column FREE OF CHARGE. Inquiries will be kept confidential if requested. Ads may be repeated in following issues at regular classified rates. Send ads to **MODERN CASTINGS, Classified Advertising Dept., Golf and Wolf Rds., Des Plaines, Ill.**

obituaries

Sheldon V. Wood, 76, organizer and chairman of the board, Minneapolis Electric Steel Castings Co., Minneapolis, and AFS President 1945-46, died May 31.

He graduated from the University of Minnesota in 1904 with a degree in Mining Engineering and for the next nine years served as an engineer and consulting engineer. In 1913 he formed Minneapolis Electric Steel Castings Co. Wood was one of the organizers of the Twin City Chapter and also a past chairman. He served as an AFS National Director 1942-1945 before assuming the presidency.

Wood also held membership in the A.I.M.E., A.S.M., Steel Founders' Society of America and the Minneapolis Engineers Society. In addition he served a number of years as Regent of the University of Minnesota, during World War II served on the War Finance Committee for the Twin City area and was a director of the First National Bank, Minneapolis.

Charles Penhaligen, 57, auditor for Dow Chemical Co., and a member of the company's finance committee, died suddenly May 8 while on business at the Dow Texas Division operations at Freeport, Texas. Penhaligen joined the Dow organization in 1936 starting as an accountant and later becoming treasurer and director of Dowell, Inc., then a Dow subsidiary and now a division. In 1941 he became Dow's auditor.

Loyal A. Tinkler, 65, a metallurgical engineer of Vanadium Corp. of America until his retirement in 1958, died in May in New York after a long illness. He was a member of the AFS Metropolitan Chapter as well as other technical societies.

Frank G. Carrington, 67, international centrifugal casting authority, died May 5 in Lynchburg, Va.

He entered the foundry field in 1911 and after service with the Army Engineer Corps during World War I. He was associated with Campbell, Wyant & Campbell Foundry Co. 1937-1940 when he joined Lynchburg Foundry Co. as a consulting engineer on equipment design and operations.

In 1945 he went with Glamorgan Pipe & Foundry Co., Lynchburg, Va., was first vice-president and general manager in charge of modernizing and operating pipe and fitting foundries. In 1954 he became associated with Pontex Corp.

He was active in several technical societies and was a past director of the AFS Piedmont Chapter.

let's get personal

Continued from page 118

Kenneth B. Larkin, formerly a district manager, appointed eastern regional manager; **Robert L. Knox,** transferred from eastern regional manager to central regional manager; **Donald O. Ross** becomes western regional manager; **Bruce C. Dennett,** formerly sales engineer, appointed assistant to regional manager; **Charles J. Bernard,** manager of the order and distribution department now directs manufacturers export sales.

B. H. Wildenhaus . . . is manager, distributor sales, Simonds Worden White Co., Dayton, Ohio. He has been with the company since 1927 and is an AFS member.

James R. Hewitt . . . formerly with Houston Equipment Co., is now with Quality Electric Steel Castings, Inc., Houston, Texas. He is a member of the AFS Texas Chapter.

Ray A. Dyke . . . formerly with Attalla Pipe & Foundry Co., Attalla, Ala., is now a metallurgist with Republic Steel Corp., Badsen, Ala. He is a member of the Birmingham Chapter.

Forst L. Robertson . . . is now vice-president and sales manager, Keokuk Steel Castings Co., Keokuk, Iowa. **Karl G. Jansson** continues as vice-president and director of sales for all companies associated with Keokuk Steel; namely Mid-Continent Steel Casting Corp., and HICA, Inc., Shreveport, La.

H. Edward Ehlers and **Warren A. Zimmer** have been elected senior vice-presidents of Joseph Dixon Crucible Steel Co., Jersey City, N. J. **Sherwood B. Seeley,** technical director, has been named vice-president in charge of research.

A. Donald Moll . . . assistant sales manager, Minneapolis Electric Steel Castings Co., Minneapolis, in addition to his previous duties has been appointed manager of technical services and sales of high alloy and stainless steel castings.

Keith D. Millis . . . assistant to the manager of International Nickel Co. Development and Research Div. at New York, has been presented with the Annual Achievement Award in Metallurgy of the New York Chapter of the American Society for Metals.

John R. Crossgrove . . . has been named as specialist-marketing research in the General Electric Co. Foundry Dept. He joined General Electric in 1957 under the company's technical marketing program.

Dr. Italo S. Servi . . . has been named as director of research of the Metals Div., Kelsey Hayes, Co. The division produces alloys by vacuum melting.

Rex Harrison . . . is now a partner in International Foundry Supply Co., Reading, Pa. He was formerly sales manager of Reading Gray Iron Castings, Inc., Reading, Pa.

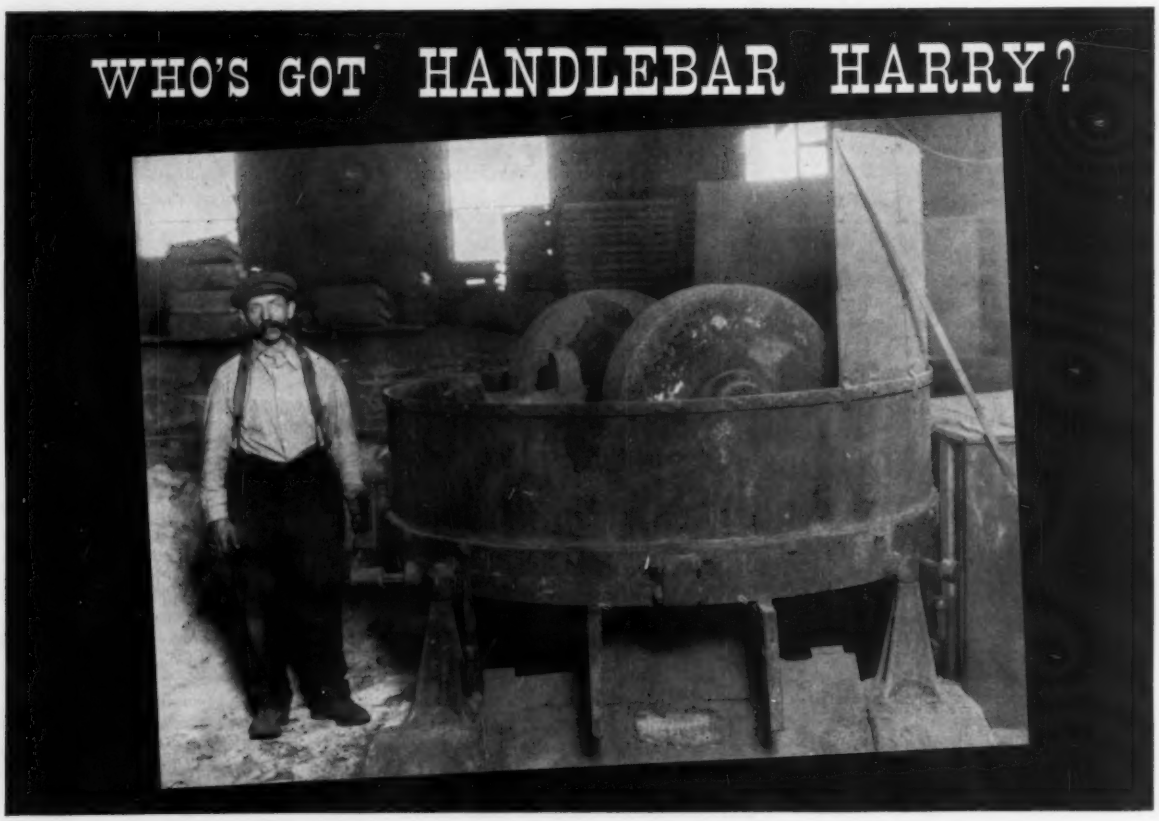
C. C. Shearer . . . is district sales manager of the Cleveland office of Bohn Aluminum & Brass Corp., succeeding **Jim Withington** who retired. Shearer was formerly production manager in Detroit for Bohn.

Leo M. Elijah . . . has been named as consultant with George Sall Metals, Inc., Philadelphia. He was formerly a senior engineer with Sylvania Electric Co.

Percy Lanning . . . is now president, Perseverance Iron Foundry, Philadelphia, succeeding James Lanning who retired after 50 years in the foundry.

Arthur VanNewkirk . . . new foundry superintendent, Abrasive Alloy Castings Co., Bridgeboro, N. J.

Phillip A. Newhart . . . has been appointed metallurgical engineer for Pig Iron & Coal Chemical Sales Div., Republic Steel Corp. He had been manager of foundries in Metal Products Div., Koppers Co., Baltimore, Md.



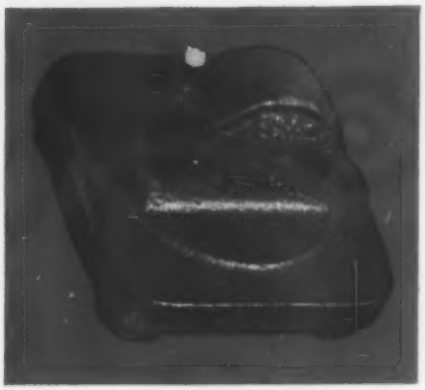
THE MOST COMMON TYPE OF PIN HOLE CAN BE ELIMINATED FROM HEAVY MALLEABLE CASTINGS WITH... GRUNDITE BOND!

HERE'S HOW: Everybody talks about pin holes, but here at last is an opportunity to do something about them.

In foundry after foundry where the most common type of pin hole was encountered, the only change necessary has been the bonding clay—when changed to Grundite Bond, these pin holes were eliminated—just as simple as that. Before Grundite and after Grundite (see photos right).

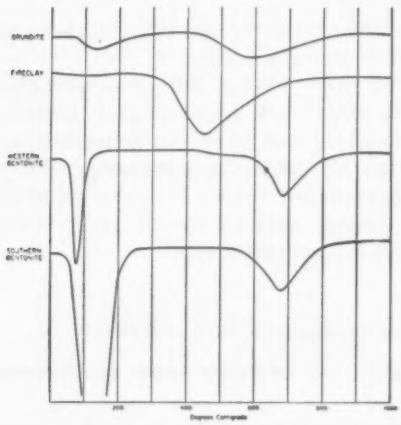
Everyone was naturally curious how Grundite made this difference. To provide a factual answer to this question, a research test was conducted at the University of Illinois. This study shows that there is a definite relationship between pin holes and the rate of water evolution from your sand molds. The graph below plots the rate of water evolution from various bonds. This, we feel, provides the logical explanation of why it is better to use Grundite than any other bond for malleable castings. See for yourself how easily pin holes, due to sand, can be eliminated from your castings when using Grundite Bond.

Write today for a demonstration in your foundry.



Before Grundite Bond was used. Note pin hole porosity . . . typical on chunky castings and often not revealed until annealing. Pin hole porosity has been proven to be related to the bond used and specifically the release of its chemically combined moisture.

After Grundite replaced the previous bond—the only change made in the sand—all pin holes stopped. Grundite Bond increases mold density with resulting smoother casting finish; faster, easier shakeouts. Scrap losses reduced.



The depth of the dips indicates volume of moisture evolution . . . the steepness of the dips indicates the rate of evolution. The adsorbed water comes off abruptly from both bentonites between 200 and 250°F. It is this sudden water vapor expulsion that causes most pin holes in malleable castings. This does not occur with Grundite Bond Clay.

ILLINOIS CLAY PRODUCTS CO.

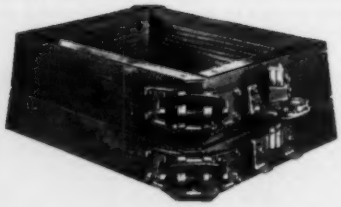
Main Office—Barber Building, Joliet, Illinois
Sales Office—208 South LaSalle Street, Chicago 4, Illinois

MANUFACTURERS OF: GOOSE LAKE Ladle Brick, Ground Fire Clay, Fire Clay Flour; GRUNDITE Bond Clay; FIROX; THERM-O-FLAKE Insulation Coating, Brick, L.B. Block, Concrete; CHEM-BRIX, Silica, Carbon

Circle No. 173, Page 131-132

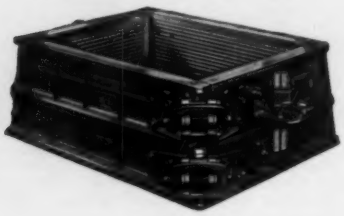
REDUCE YOUR COSTS

ADAMS Cast Iron or Cast Aluminum Jackets



CHERRY EASY-OFF FLASK

ALUMINUM EASY-OFF FLASK



Look at these features and you'll agree that the Adams line can mean economy, efficiency, and better molds for your foundry.

Above is the Adams jacket available in either cast iron or cast aluminum. They are cast from a top grade metal mixture best suited for their purpose. The sturdy construction as a result of the vertical ribs inside and horizontal ribs outside plus the handles at either end assure you of long life for this equipment and ease in handling. These jackets afford you MAXIMUM STRENGTH with MINIMUM WEIGHT.

Here are jackets that assure you perfect mold fit—will give you the greatest strength while under pouring strain—allow for free flow of gases all because of INSIDE CORRUGATIONS. These VENTILATED jackets are first choice in foundries across the nation.

Look into the advantages cast iron or cast aluminum can offer you depending upon your foundry needs. We will be happy to make recommendations to fill your requirements.

For the most complete line of flask equipment available . . . always look to Adams!

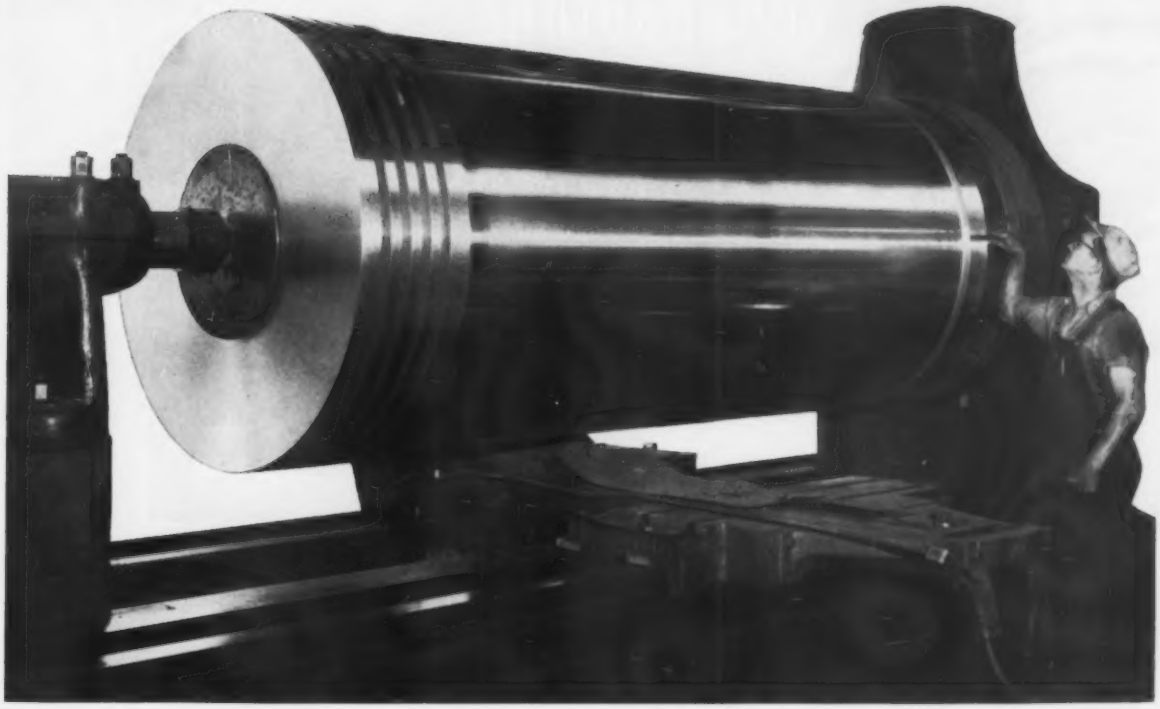
The ADAMS Company

ESTABLISHED 1883

MOLDING MACHINES and FLASK EQUIPMENT

700 FOSTER ST., DUBUQUE, IOWA, U.S.A.

Circle No. 158, Page 131-132



51,300 Pounds of Skilled Workmanship and . . .

This main ram for a hydraulic press was made by the Goslin-Birmingham Manufacturing Company of Birmingham, Ala., under the most exacting specifications. A 32-40 micro-finish was required. Moulding, casting, machining and polishing required the highest foundry and machine shop skills. The iron used was Woodward malleable, which has demonstrated its outstanding dependability in the production of quality castings of all types and sizes.

DEPENDABLE **WOODWARD IRON**

For quotations, write or call our Sales Department, Woodward, Ala.
Phone Bessemer, Ala. HAmilton 5-2491
or Sales Agents for territory North of Ohio River:
HICKMAN, WILLIAMS & COMPANY with Sales Branches at—

609 Bona Allen Building, Atlanta 3, Ga.; 230 North Michigan Avenue, Chicago 1, Ill.; First National Building, P. O. Box 538, Cincinnati 1, Ohio; 1659 Union Commerce Building, Cleveland 14, Ohio; 1203 Ford Bldg., Detroit 26, Mich.; P. O. Box 335, Duluth 1, Minn.; 412 Guaranty Bldg., Indianapolis 4, Ind.; 70 Pine St., New York 5, N. Y.; 1500 Walnut Street Bldg., Philadelphia 2, Pa.; 1910 Clark Bldg., Pittsburgh 22, Pa.; 902 Syndicate Trust Bldg., St. Louis 1, Mo.

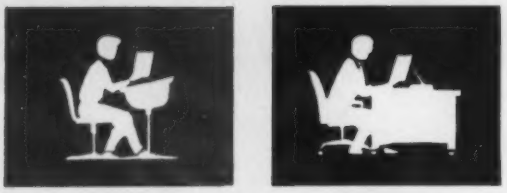
WOODWARD IRON COMPANY

WOODWARD IRON COMPANY

WOODWARD, ALABAMA

Independent Since 1882

IT'S UP TO YOU!



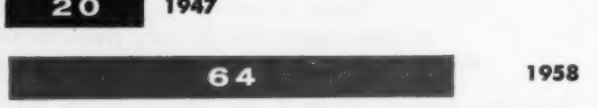
The students who are interested in the foundry industry today are the industry's management of tomorrow.

One of our jobs, as the Foundry Educational Foundation, is the encouragement of, and assistance to, these students.

Over the past nine years, as you can see from the accompanying chart, F.E.F. has made great strides in that direction. Sixty-four departments now require students to study the cast metals industry, as compared to only twenty in 1947.

This advancing trend will assure a continuing flow of capable, well-educated young men into our industry . . . **providing** your interest and financial support are maintained now and in the future.

DEPARTMENTS REQUIRING CAST METALS STUDY



Write for our new booklet, "Let's Look Ahead".

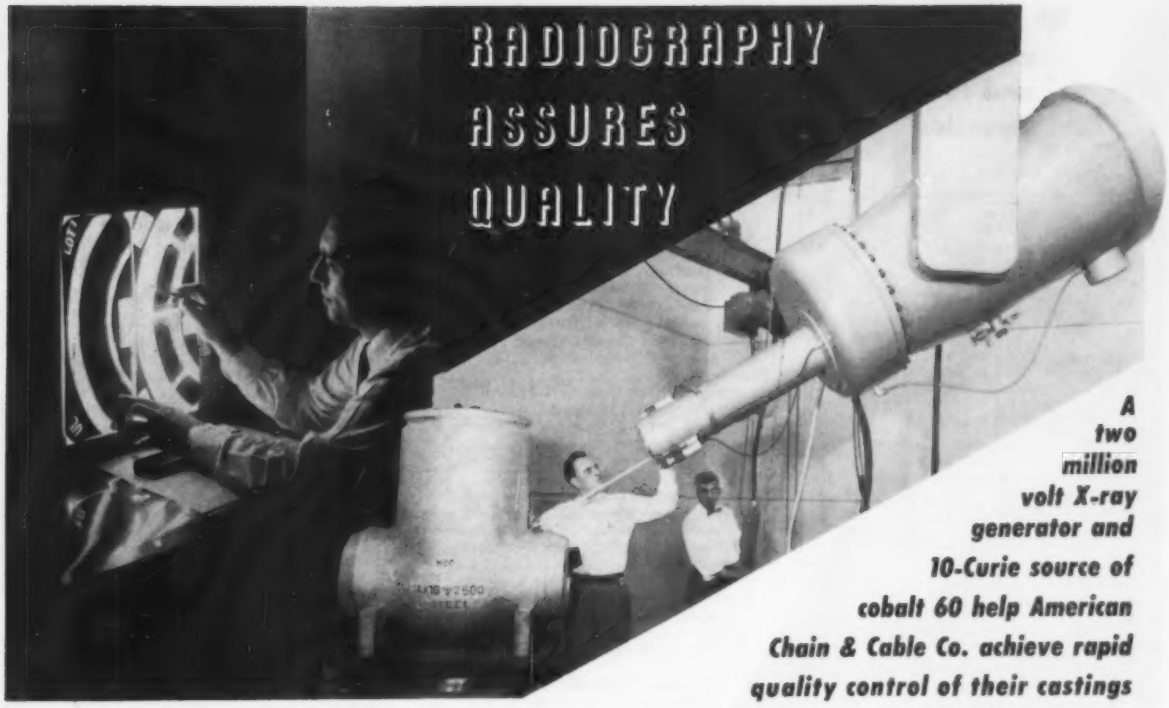
You'll be glad you did.

Foundry Educational Foundation

1138 TERMINAL TOWER BUILDING • CLEVELAND 13, OHIO

Circle No. 174, Page 131-132

RADIOGRAPHY ASSURES QUALITY



A two million volt X-ray generator and 10-Curie source of cobalt 60 help American Chain & Cable Co. achieve rapid quality control of their castings

■ The installation of a two-million volt Van de Graaf electrostatic generator and its companion ten-curie source of cobalt 60, has helped the steel castings and valve divisions of American Chain & Cable Co., Reading, Pa., achieve an unparalleled high productivity record.

The new equipment handles all inspection needs with speed and definition acceptable to critical inspection code requirements and overcomes previous handicap caused by a lack of high-voltage x-ray equipment and low-energy source of cobalt 60.

Need for new equipment was brought about by: 1) increasing trend for customers specifying x-ray inspected castings; 2) increased demand in power industry for quality castings; 3) increased work load on high-pressure valves for multi-industry needs such as chemicals, petrochemicals, wastes; 4) necessity of x-raying pilot models of castings and pressure seals to insure lowered production costs.

In securing new equipment the greatest factor to be considered was safety; the greatest factor in safety was distance. The new building was designed and built on a tract of land close to the main foundry and mill. High-density concrete walls that measured 48 inches in thickness housed the generator. Access to this part of the building is through a sliding door, also 48-in. thick, weighing approximately 5-1/2 tons. Motor-drive opens and closes door in seconds to permit personnel to pass in and out of the chamber.

Gamma-ray sections of the structure has walls 24 inches thick and is equipped with same type door weighing approximately 2-1/4 tons. Winding corridors permit passage from one section of building to the other without radiation exposure.

With exposure time greatly reduced, handling and set-up time becomes of paramount importance. Castings on carts are pulled by lift truck into the inspection chambers. Concrete road beds, leading from cleaning rooms to the specially constructed building, have been installed for smoother delivery of heavy metal castings.

All heavy-walled castings are delivered to inspection after cleaning. They are then set on a huge hand-driven turntable with adjustable blocks. This arrangement allows the x-ray target to remain constant while castings are manipulated for each exposure.

The gamma-ray facility utilizes 10 Curies of cobalt 60 in a chamber which has dead center marked with the special seal of the Atomic Energy Commission. Around this identification spot are marked three permanent concentric circles of 5, 10 and 20 ft in diameter. This eliminates measuring from the source of gamma-ray to the accurately placed castings.

Twenty small castings can be manually placed around the predetermined focal distance circle. Then castings are stamped and films attached. With flexible cable set in the center of circle, operator leaves chamber, closes all access doors and proceeds to crank out source of cobalt 60. On completion of exposure, gamma-ray source is then cranked back into its lead storage container. Operator then enters the room with complete safety, removes films, identifies exposed area with lead letters, sets new film into position, leaves room and cranks out the gamma-ray source for second exposure, 180 degrees from original position.

To facilitate processing of exposed films they are developed and interpreted in the same building where a complete darkroom, control room and viewing room has been constructed behind the safety of a four-ft thick high-density concrete wall.

C. N. Johns, president of American Chain & Cable, states "Being on stream with our new facilities and with rapid exposure time in using the new x-ray generator and 10 Curie source of cobalt 60 puts us in a position to manufacture and accomplish all pressure-seal bodies and bonnets; all 900 and 1500–lb bolted bonnet bodies and bonnets; and solicit quality x-ray casting business from a larger group of users. We are now adequately equipped to take care of better than average conditions. The new radiographic team puts us in a position of producing sounder castings, with earlier delivery and reduced cost."

advertisers and their agencies

Abrasive Shot & Grit Co., Inc. 112
Agency—Wellman-Buschman Co.

Adams Company 124
Agency—W. D. Lyon Co.

Allied Chemical Corp. 117
Agency—Benton & Bowles, Inc.

Allis-Chalmers Mfg. Co.
Engine-Materials Div. 10
Agency—Bert S. Gittins Adv. Inc.

Apex Smelting Co. .....Back Cover
Agency—Doremus & Co.

Archer-Daniels-Midland Co. 11, 115
Agency—Bayless-Kerr Co.

Beardsley & Piper Division
Pettibone Mulliken Corp. 9
Agency—Ladd, Southward & Bentley, Inc.

Carver Foundry Products Co. 3
Agency—Warren & Litzenberger

Cities Service Oil Co. 24
Agency—Ellington & Co., Inc.

Cleveland Flux Co. 17
Agency—Brad Wright Smith Adv., Inc.

Foundry Educational Foundation 126

Foundry Services, Inc. 116, 128, 130
Agency—Kight Advertising, Inc.

Holtzman Metal Co. 112
Agency—Milton Sharp, Adv.

Frank G. Hough Co. 14
Agency—Ervin R. Abramson, Adv.

Illinois Clay Products Co. 123
Agency—Connor Associates, Inc.

Industrial Equipment Co. 113
Agency—Central Adv. Agency

International Foundry Supply Co. 128
Agency—Marge Roland

International Nickel Co. 19
Agency—Marschalk and Pratt

Kaiser Aluminum & Chemicals Sales, Inc. . 16
Agency—Young & Rubicam

Lectromelt Furnace Co. 15
Agency—Griswold-Eshleman Co.

Linde Company 119
Agency—J. M. Mathes, Inc.

Modern Castings 118

Modern Equipment Co. 4
Agency—Jay Ferch & Associates

National Engineering Co. 6, 7
Agency—Russell T. Gray, Inc.

National Metal Abrasive Co. Inside Back Cover
Agency—G. A. Saas and Co.

North American Refractories Co. 12
Agency—Clifford A. Kroening, Inc.

Ohio Ferro-Alloys Corp. 21
Agency—Frease & Shorr Adv.

Olin Mathieson Chemical Corp. 129
Agency—D'Arcy Advertising Co.

Oliver Machinery Co. 112
Agency—Ben Dean Adv. Agency

Pettibone Mulliken Corp. 9
Agency—Ladd, Southward & Bentley, Inc.

Pittsburgh Crushed Steel Co. 8
Agency—Coleman Todd & Associates

Reichhold Chemicals, Inc. 13
Agency—MacManus, John & Adams, Inc.

Royer Foundry & Machine Co. 18
Agency—Richardson, Thomas & Bushman, Inc.

Alexander Saunders & Co. 130
Agency—Steve Devore Co.

Semet-Solvay Div. Allied Chemical Corp. 117
Agency—Benton & Bowles, Inc.

Sterling National Industries, Inc. 23
Agency—Hoffman, York, Paulson & Gerlach

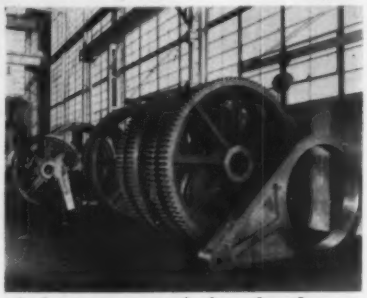
Union Carbide Metals Co. .Inside Front Cover
Agency—J. M. Mathes, Inc.

Universal Clay Products Co. 20
Agency—Scheel Adv. Agency

Woodward Iron Co. 125
Agency—Sparrow Adv. Agency

here's how

HERE'S HOW . . . . Federal Engineering Co., Detroit, obtained ductile iron gears and connecting rods with sufficient strength for a 2000-ton capacity eccentric type tryout press. Gears were made by the Beloit Foundry Co., South Beloit, Ill., and the rods by Lansing Foundry Div., Detroit Gray Iron Co. The designer



of the press stated that ductile was used because it provided the strength required for gear teeth without sacrificing the good wearing surfaces on tooth faces. Connecting rods were said to have been designed with as small a cross section as would have been possible with steel.

Too busy to "get away" to inspect a proposed installation? SEE

REVECON
FURNACE

Mobile Demonstration Unit

—a traveling working Revecon Furnace available for

Free Demonstration At Your Foundry

Here's what a Demonstration will prove right in your own Foundry under your working conditions using your metal:

- Melts 100 lbs. Aluminum in 12 min. using 0.7 gal. oil or 100 cu. ft. gas*.
- Melts 200 lbs. Brass/Bronze in 20 min. using 1.2 gal. oil or 130 cu. ft. gas* per 100-lbs.
- Melts 175 lbs. Copper in 35 min. using 1.5 gal. oil or 150 cu. ft. gas* per 100-lbs.
- Melts 100 lbs. Iron in 55 min. using 3.4 gal. oil or 360 cu. ft. gas*.

* 1040 BTU gas.

Metal loss: Al—under 1%; Brass/Bronze—under 2%.

See HOW and WHY Revecon Saves You 50% of your Melting Costs

Check your present costs against these Savings and you can't afford to miss this Demonstration at your Foundry. Unit is 9' high including spark arrester, 12' long, 79½" wide. Oil or gas fired.

For Details on FREE DEMONSTRATION Write

International Foundry Supply Co., P. O. Box 1053, Reading, Pa. phone: FR 6-0794

Circle No. 176, Page 131-132

Cut casting costs, eliminate shrinkage, reduce scrap with

Foseco FEEDEX®

exothermic anti-piping compounds for increased feeding efficiency

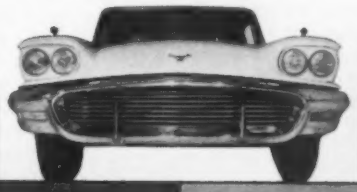
This bulletin tells you how. Send for your free copy today.

Foseco®
FOUNDRY SERVICES, INC.
P. O. Box 8728, Cleveland 35, Ohio

Circle No. 177, Page 131-132

.....Today the proudest cars on the road glisten with Olin Aluminum

The exciting Ford Thunderbird is an example. Quality Olin Aluminum is going into the manufacture of most of the fine new cars. Bright, light aluminum resists corrosion, won't rust. No other metal gives car owners such lasting satisfaction. Olin Aluminum, in its first year as a major producer, is already a basic source of supply for the great names in the automotive industry.



OLIN ALUMINUM

OLIN MATHIESON • METALS DIVISION • 400 PARK AVE., N. Y.

Circle No. 178, Page 131-132

Eliminate oxides, dirt and other impurities from aluminum and zinc melts with

Foseco COVERALS

and get metal-free drosses, too!

This bulletin tells you how. Send for your free copy today.

Foseco

FOUNDRY SERVICES, INC.
P. O. Box 8720, Cleveland 25, Ohio

Circle No. 179, Page 131-132

New Improved Ceramic Shell Molds Cut Process Time 50% ...Material Cost 40%

You, too, can now enjoy the benefits of the complete Naicast mold making system like many leading investment casting foundrymen. Less process time...lower material cost...closer tolerances...larger castings...simpler methods, are some. Ask us for the full story. See how easily you can install this system to save time and money. No obligation, of course.

FAST, DEPENDABLE SERVICE

As Eastern distributor of Naicoag and Naicast for National Aluminate Corporation of Chicago, Alexander Saunders & Company can serve you quickly and dependably.

Phone or write us for your Naicast needs or for conventional investment casting requirements. For both, we recommend—

• Saunders Blue Wax • Sherwood Wax Injection Presses • Ecco High Frequency Melting Equipment • and many other proven products

Send for Catalog #56 for complete listing and description.

ALEXANDER SAUNDERS & CO.

95 Bedford Street, New York 14, New York

Circle No. 180, Page 131-132

SHELLMOLDING

By J. F. Oettinger
Electric Steel Foundry Co.
Portland, Ore.

The shellmolding process is used for almost every alloy you can imagine. In our case, we pour into shell everything from plain mild steel to alloys where iron is a trace element. However, the widest use, in terms of tonnage poured, is for cast iron which lends itself well to the advantages you can get from shellmolding.

Zircon and olivine may be found worth using instead of, or with, silica in spite of higher costs; zircon because of its greater heat transfer and stability under thermal shock; and olivine because of its chemical reaction with molten metal.

Additives to the mix—iron oxide, silica or zircon flour, or other metallic oxides—have all found use in various foundries. These additives act by either chemical re-action with the molten metal in the mold or by filling the voids between the sand grains in the mold.

The resin binders are all two-stage thermo-setting resins. The largest tonnage is used as a dry mix in which the powdered resin is mixed with the sand in a dry state; but an increasing tonnage is being used as a coating mix. This coating procedure may be accomplished with or without heat.

A word about patterns is essential to any discussion of shellmolding. Aluminum is a satisfactory material for short runs and is relatively cheap; however, it wears rapidly and is dimensionably unstable. Bronze and cast iron are much better choices if the cost can be justified. Either is wear-resistant and unaffected by repeated temperature cycling. Bronze is often chosen over cast iron for its greater heat conductivity.

It's possible to achieve quite close dimensional tolerances with shell-molded castings. The use of closely machined patterns and a hard, rigid mold make it possible to produce castings with tolerances of + or −.005 in. per in. of dimension or less. One foundry has held + or −.002 in. on a 1-in. dimension on production runs of thousands, but, on the other hand, some jobs seem impossible to bring down under + or −.010 in. The parting-line problem is something to be dealt with individually, but an addition of + or −.010 in. across the parting is normal.

A good surface finish can be achieved with shell, depending almost entirely on the alloy, on the section of the casting and on the gating practice. Regarding alloy, mild steel is difficult to cast with a surface much better than 500 microinch. In our shop we have gotten down to 125 microinch, but these are small castings with light sections. We consider 250 microinch a good job on a section of 1/2 in. On high alloy steel, 250 microinch is not unusual, but this again depends on the section and the gating. In iron and nonferrous alloys, 250 microinch or better is standard.

Thus far, there does not seem to be any limit to the casting size that can be accomplished in a shellmold; 200-lb mild steel projectile castings and 80-lb iron crankshafts are good examples. ESCO has poured stainless rocket engine components with a 175-lb pour weight. These castings required a + or −0.030 in. tolerance on a 20 in. dimension. In low alloy, we have poured 90 lb into shells for a 70-lb clean weight and held a + or −0.030 in. on 12-in. dimensions. On the other end of the scale are some stainless valve levers with a clean weight of about 1/2 ounce, with a tolerance of + or −0.005 in. all over.

Shell molding offers at least five major advantages: 1) ease of manufacture and mechanization; 2) elimination of machining by making a close-tolerance casting with an excellent surface finish; 3) improved surface appearance; 4) reproductibility; and 5) consistency.

Shellmolding will not replace machining tolerances in all cases. If any finish at all is required on the surface, it is essential that sufficient finish be provided. It is far harder for a machinist to set up to 1/32-in. or 1/64-in. finish that it is to 1/16 in. or 1/8 in. This causes the overall machining costs to climb.

ESCO is pouring approximately 10 tons of steel per day into shell molds. Out of this 10 tons, well over 90 per cent are items that could be made equally well in green sand. But shell is being used because it costs us less to make the castings and often leads to new business.

Editor's Note: This article contains highlights excerpted from a talk presented at the 1958 AFS Northwest Regional Conference.

modern castings is the BIGGEST magazine in the metalcastings industry

There are more pages of top technical editorial material in MODERN CASTINGS . . . 1400 pages in the last year . . . and you can receive a personal copy of this valuable publication each month for only $5.00 a year in the U.S., $7.50 elsewhere.

To subscribe, complete the information on one of the cards below and mark the box ☒ at the bottom of the card. You will be billed later.

modern castings is the BEST source of manufacturers' data

When you see a "Circle No." under an item or an ad, it means that there is more information available to you by using the cards below. MODERN CASTINGS fills more of these inquiries than any other publication in the metalcasting industry.

Please type or print Void after January 1, 1960 **July/59**

Please have information or bulletins indicated by circled numbers sent to me without obligation.

Name _____ **Title** _____

Company _____

Address _____

City _____ **Zone** _____ **State** _____

1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205	217	229
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206	218	230
3	15	27	39	51	63	75	87	99	111	123	135	147	159	171	183	195	207	219	231
4	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184	196	208	220	232
5	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185	197	209	221	233
6	18	30	42	54	66	78	90	102	114	126	138	150	162	174	186	198	210	222	234
7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187	199	211	223	235
8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212	224	236
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213	226	238
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214	225	237
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215	227	239
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240

☐ I wish to subscribe to MODERN CASTINGS — bill me later.

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 83, Sec. 34.9 P. L. & R. DES PLAINES, ILL.

Reader Service Dept.
MODERN CASTINGS
Golf & Wolf Roads
Des Plaines, Illinois

modern castings is the BIGGEST magazine in the metalcastings industry

There are more pages of top technical editorial material in MODERN CASTINGS . . . 1400 pages in the last year . . . and you can receive a personal copy of this valuable publication each month for only $5.00 a year in the U.S., $7.50 elsewhere.

To subscribe, complete the information on one of the cards below and mark the box ☒ at the bottom of the card. You will be billed later.

modern castings is the BEST source of manufacturers' data

When you see a "Circle No." under an item or an ad, it means that there is more information available to you by using the cards below. MODERN CASTINGS fills more of these inquiries than any other publication in the metalcasting industry.

Postage Will be Paid by Addressee

No Postage Stamp Necessary If Mailed in the United States

BUSINESS REPLY CARD
First Class Permit No. 83, Sec. 34.9 P. L. & R. DES PLAINES, ILL.

Reader Service Dept.
MODERN CASTINGS
Golf & Wolf Roads
Des Plaines, Illinois

Please type or print **Void after January 1, 1960** **July/59**

Please have information or bulletins indicated by circled numbers sent to me without obligation.

Name _____ **Title** _____

Company _____

Address _____

City _____ **Zone** _____ **State** _____

1	13	25	37	49	61	73	85	97	109	121	133	145	157	169	181	193	205	217	229
2	14	26	38	50	62	74	86	98	110	122	134	146	158	170	182	194	206	218	230
3	15	27	39	51	63	75	87	99	111	123	135	147	159	171	183	195	207	219	231
4	16	28	40	52	64	76	88	100	112	124	136	148	160	172	184	196	208	220	232
5	17	29	41	53	65	77	89	101	113	125	137	149	161	173	185	197	209	221	233
6	18	30	42	54	66	78	90	102	114	126	138	150	162	174	186	198	210	222	234
7	19	31	43	55	67	79	91	103	115	127	139	151	163	175	187	199	211	223	235
8	20	32	44	56	68	80	92	104	116	128	140	152	164	176	188	200	212	224	236
9	21	33	45	57	69	81	93	105	117	129	141	153	165	177	189	201	213	225	237
10	22	34	46	58	70	82	94	106	118	130	142	154	166	178	190	202	214	226	238
11	23	35	47	59	71	83	95	107	119	131	143	155	167	179	191	203	215	227	239
12	24	36	48	60	72	84	96	108	120	132	144	156	168	180	192	204	216	228	240

☐ I wish to subscribe to MODERN CASTINGS — bill me later.

PERMABRASIVE®

are you *Satisfied* with your blast cleaning operation?

Even if you believe you are getting good results now, you cannot afford to hang out the "Do Not Disturb" sign. If you are interested in cleaning speed, finish, abrasive consumption, or maintenance costs, listen to this:

NATIONAL has learned to control its melts to such a fine point, that we are able to turn out abrasives with controlled characteristics and predictable results ton after ton after ton. **PERMABRASIVE®**, the pearlitic malleable abrasive, annealed practically a pellet at a time, is enjoying a ten year record of saving money for thousands of cost-conscious customers.

Here's what this means: If you are using steel abrasives, **PERMABRASIVE®** can save you money, because of its faster cleaning action and lower cost per ton. If you are using ordinary annealed abrasives you can save money by buying **PERMABRASIVE®**, because of its faster cleaning action, minimum graphitic carbon, and longer life, because of its low phosphorus content. And—where special problems call for a custom-designed abrasive—NATIONAL can and does produce it, because of a decade of experience in the fine art of controlling its melts. Simply put: our metallurgists KNOW what it takes to get certain results and KNOW how to build it into our shot and grit.

This is no cock and bull story, but a fact. Try us. We can prove our points—simply—in your own plant, under your own conditions, without upsetting your operational apple cart.

We also make **PERMA-STEEL®**, the low cost "work-horse" of the long-life abrasives, which may fit your special operation perfectly to produce many of the same cost-cutting advantages. If you have an application that calls for a chilled iron shot and grit, try our **CONTROLLED "T"®**, the "iron fist in a velvet glove." In short, NATIONAL makes an abrasive to cover every possible blast cleaning need.

FREE: the NEW "Second Reader on the use of shot and grit." Write for your copy.

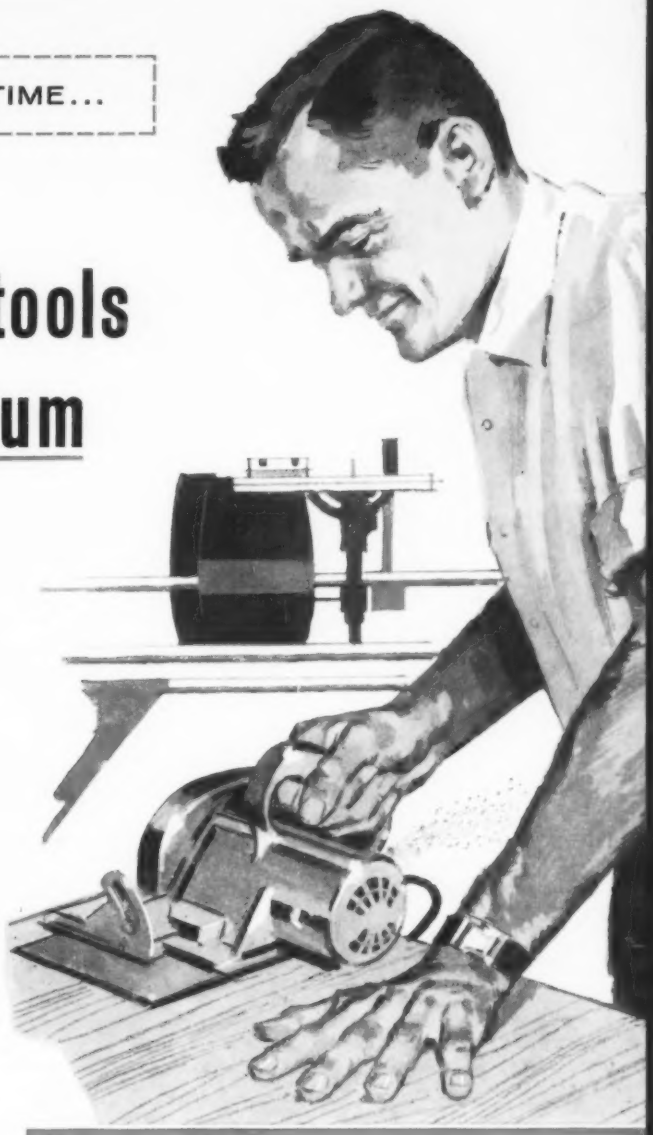
Sold Exclusively by
HICKMAN, WILLIAMS & COMPANY (Inc.)
Chicago · Detroit · Cincinnati · St. Louis · New York · Cleveland · Philadelphia · Pittsburgh · Indianapolis

Exclusive West Coast Subdistributors
BRUMLEY-DONALDSON COMPANY
Los Angeles · Oakland

NATIONAL
METAL ABRASIVE COMPANY
3560 Norton Rd. • Cleveland 11, Ohio
Western Metal Abrasives Co. (Affiliate)
101 E. Main Street • Chicago Heights, Illinois
Sole manufacturers of Permabrasive® and Controlled "T"® abrasives

FOR A BETTER JOB IN LESS TIME...

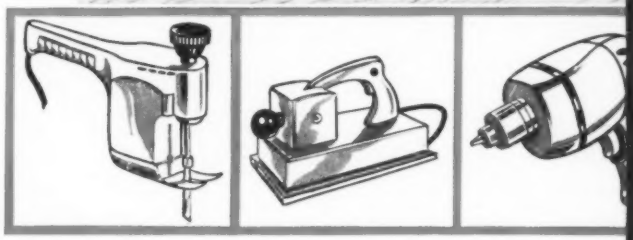
he's using power tools made with aluminum



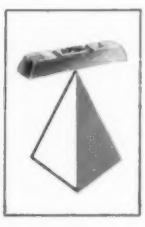
Today's homeowner is handier than ever and the professional works faster, delivers a better job—thanks to power tools and the versatility of aluminum. Whether you're sawing, sanding or drilling, these specialized tools provide the modern, easy way to finish the task.

Lightweight aluminum helps make power tools more portable, easier to handle. They give better service and last longer because aluminum is stronger. It's the one metal that resists rust, corrosion, pitting and chipping, always stays new looking. Too, manufacturers prefer aluminum because it can be formed in many ways, is easy to machine, and saves costly production steps.

Apex Smelting Company and its metallurgists work closely with the foundries and die casters who serve the power tool industry. Custom and standard aluminum alloys, scientifically produced by Apex to rigid specifications, are providing the performance and quality you want in these modern day work-savers.



Research leadership back of every ingot



APEX SMELTING COMPANY

Producers of ALUMINUM, MAGNESIUM AND ZINC ALLOYS

CHICAGO 12 CLEVELAND 5 LONG BEACH 10, CAL.
SPRINGFIELD, OREGON (National Metallurgical Corp.)

Your products may also be produced better and more efficiently with the help of aluminum castings. Apex Smelting and the companies it serves in the die casting and foundry industry stand ready to assist you and your engineers.

Circle No. 182, Page 131-132